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SHORT COMMUNICATION

LEAD, MANGANESE, AND CADMIUM CONTENT IN PM_{10} AND $PM_{2.5}$ PARTICLE FRACTIONS – A PILOT STUDY

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This paper describes a pilot study of lead, manganese, and cadmium content in thoracic particle fraction and high-risk respirable fraction of airborne particles. Samples were collected at one measuring site in Zagreb during autumn 1998 and spring 1999. The results show that the total heavy metal content is found in the high-risk respirable particle fraction, and point to two main pollution sources, the first for lead and manganese and the other for cadmium.

Key words:
heavy metals, high-risk respirable particle fraction, pollution source, thoracic particle fraction

Due to different adverse health effects, heavy metal content in thoracic and high-risk respirable particle fractions in the air is one of the main reasons for assessment of air pollution. Lead, manganese, and cadmium content in total suspended particulate matter collected from ambient air has been measured in Zagreb since the beginning of the seventies (1). This paper presents the results of a pilot study of lead, manganese, and cadmium content in PM_{10} and $PM_{2.5}$ particle fractions in the Zagreb air, with the aim to get an insight in the population's intake of heavy metals by respiration.

MATERIALS AND METHODS

Sampling

Twenty-four-hour samples of PM_{10} and $PM_{2.5}$ particle fractions were collected during the heating season (autumn 1998 and spring 1999) at one sampling site located in

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the northern, residential part of Zagreb with moderate to high traffic density. Fractions coarser than those defined by collection parameters were removed from the air stream by inertial impactors, and the samples of fine particle fractions were collected on membrane filters (Millipore SSWP09025; AAWP09025; pore size 0.8 μm) at the average air flow rate of 70 L/min from approximately 100 m^3 of ambient air (2).

Sample analysis

Mass concentrations of PM_{10} and $PM_{2.5}$ fractions were determined using the gravimetric method. Prior the mass determination, before and after sampling, filters were preconditioned to constant humidity (1.25 g/m^3, 30.5 °C) in a desiccator containing $CaCl_2$ over 24 hours. One half of each sample was destroyed in nitric acid and the lead, manganese, and cadmium contents were determined by flame atomic absorption spectrometry (3).

RESULTS AND DISCUSSION

Table 1 summarises mass concentrations of lead, manganese, and cadmium for both particle fractions. Since the distribution of concentrations tends to be log-normal ($p<0.001$), medians and geometric standard deviations were chosen as the measures of a central tendency. The column showing average concentrations serves only for comparison. The regression analysis (Figure 1) of the metal content shows that the differences in mass concentrations between the two particle fractions are small, indicating that lead, manganese, and cadmium are mainly present in a $PM_{2.5}$ particle fraction.

Table 1 *Mass concentrations of lead, manganese, and cadmium in airborne particles ($\mu g/m^3$)*

	N	Median	σg	Average
Pb–10	125	0.0944	2.08	0.1260
Pb–2.5	125	0.0951	2.09	0.1277
Mn–10	122	0.00308	1.91	0.00378
Mn–2.5	122	0.00311	1.92	0.00382
Cd–10	121	0.000609	1.71	0.000685
Cd–2.5	121	0.000613	1.72	0.000690

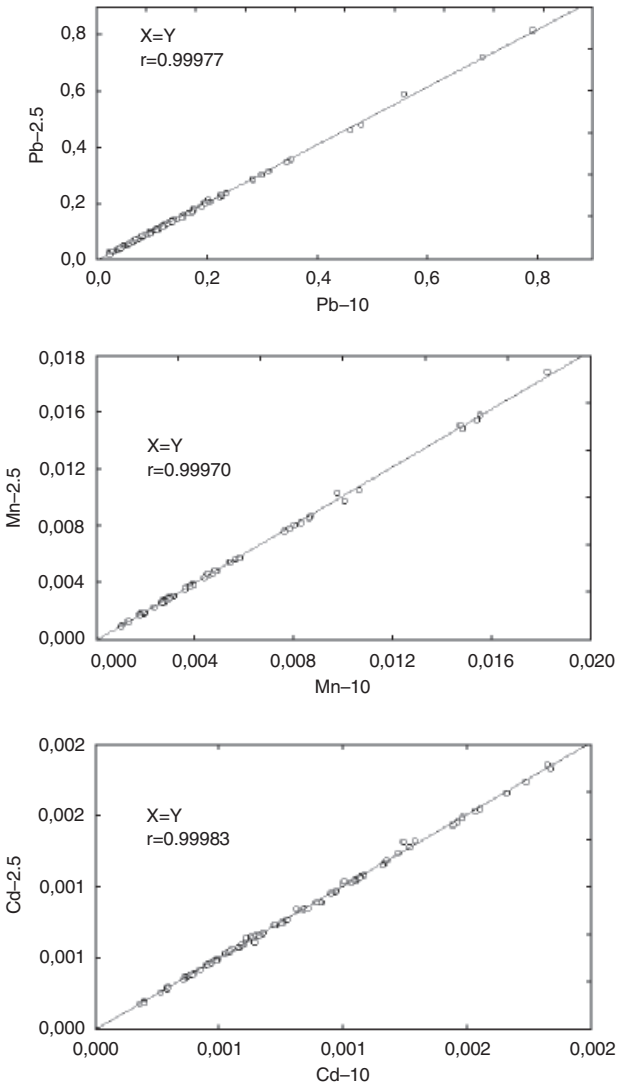

Figure 1 *Regression between mass concentrations of lead, manganese and cadmium in PM_{10} and $PM_{2.5}$ particle fractions (μgm^{-3})*

Table 2 shows correlations between pollutant concentrations for both particle fractions. A highly significant correlation was found between particle mass, lead, and manganese concentrations for both particle fractions (>50% of common variance), which suggests that the pollutants may have the same source. Lower correlations between cadmium concentrations and other pollutant concentrations could partly be

Table 2 *Correlations between pollutant mass concentrations (P<0.001)*

	Pb–10	Mn–10	Cd–10		Pb–2.5	Mn–2.5	Cd–2.5
PM_{10}	0.6943	0.7232	0.3751	$PM_{2.5}$	0.7456	0.735	0.3889
Pb–10		0.7234	0.3607	Pb–2.5		0.7313	0.3770
Mn–10			0.524	Mn–2.5			0.5299

attributed to low cadmium concentration levels and partly to a possibility that cadmium originated from a source other than that of lead and manganese.

To confirm these findings, we ran a factor analysis with eight variables. We extracted two factors which accounted for 86.9% of the variance (Table 3). The first factor shows strong relation between particle mass, lead, and manganese, while the second is related to cadmium, which corroborates the above interpretations.

Table 3 *Factor loadings*

	Factor 1	Factor 2
PM_{10}	0.8701	0.1828
$PM_{2.5}$	0.8971	0.1779
Pb–10	0.9033	0.1502
Pb–2.5	0.9031	0.1472
Mn–10	0.8149	0.4072
Mn–2.5	0.8226	0.4025
Cd–10	0.2105	0.9714
Cd–2.5	0.2255	0.9673
Variance (%)	57.9	29.0

CONCLUSIONS

The results show that almost all lead, manganese, and cadmium content is found in $PM_{2.5}$ particle fraction. Highly significant correlations found between particle mass, lead, and manganese concentrations for both fractions (>50% of common variance) indicate that these pollutants probably originate from the same source.

The lack of correlation between cadmium concentrations and concentrations of the other two metals as well as their smaller variability in the Zagreb air lead to the conclusion that cadmium originated from a different source.

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Sažetak

SADRŽAJ OLOVA, MANGANA I KADMIJA U INHALABILNOJ I RESPIRABILNOJ FRAKCIJI LEBDEĆIH ČESTICA – PRVA ISTRAŽIVANJA

Prikazani su početni rezultati određivanja sadržaja olova, mangana i kadmija u inhalabilnoj i respirabilnoj frakciji lebdećih čestica mjerenih na jednome mjernom mjestu u Zagrebu tijekom jeseni 1998. i proljeća 1999. godine. Iz rezultata je vidljivo da se cjelokupan sadržaj istraživanih metala nalazi u respirabilnoj frakciji čestica. Dominiraju dva izvora onečišćenja, jedan za čestice, olovo i mangan te drugi za kadmij. Istraživanja se nastavljaju.

Ključne riječi:
inhalabilne čestice, izvor onečišćenja, respirabilne čestice, teški metali

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