CO-OCCURRENCE OF MERCURY AND CARBON IN SIZE-SEGREGATED PARTICULATE MATTER IN URBAN AIR

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Introduction

The main goals of the presented study were to investigate ambient concentrations of particle bound mercury (PBM) and to assess the Hg content in the finest PM particles in southern Poland, a region of high particulate matter (PM) emissions. Atmospheric mercury and carbon have a common origin (combustion and thermal processing of fuels and minerals), therefore their contents in PM are supposed to be in some relation. In southern Poland, where PM comes mainly from coal combustion, this relation has been supposed to be especially distinct. In this study, an attempt is presented at showing that the way Hg and C co-occur in several PM size fractions can support reasoning on the origin of PBM.

Methods and sampling sites

The measurements were conducted in Zabrze (180,000 inhabitants), one of the 14 cities making together the 2 million Upper Silesian Agglomeration (Poland); the area is one of the European air pollution hot-spots. Zabrze has very poorly developed central heat distribution system, most detached houses being individually heated by coal combustion. There are two cokeries and several coal fired heat and power plants within the city and in its close vicinity. PM was sampled at two sites situated within the city: one in the center, close to the big crossroads, and the second in the residential area, beyond the road traffic effects. PM samples were collected in 3-day exposure periods from April to October of 2013.
PM was sampled with 2 identical 13-stage Dekati impactors (DLPI, Dekati Ltd.). The masses of the PM samples were determined gravimetrically; a MYA 5.3Y.F (Radwag) micro balance was used. Hg content of PM was determined by applying cold-vapor atomic absorption spectrometry to thermally decomposed PM samples; an MA-2 analyzer (Nippon Instr. Co) was used. Organic and elemental carbon contents of PM were determined with the use of a Dual-Optical Carbonaceous Analyzer (Sunset Lab. Inc.) according to the EUSAAR-2 protocol. Both methods are described in Rogula-Kozłowska, 2014, and Pyta and Rogula-Kozłowska, 2016.

Results

Table 1. Mean concentrations of $PM_{0.1}$, PM_1, $PM_{2.5}$, PM_{10}, and total PM (TSP) (μg m^{-3}) and PM-bound mercury (PBM, pg m^{-3}), organic carbon (OC, μg m^{-3}) and elemental carbon (EC, μg m^{-3}) at two sites in Zabrze.

PM fraction	Zabrze – city center				Zabrze - residential area			
	PM	PBM	OC	EC	PM	PBM	OC	EC
$PM_{0.1}$	1.3	4.4	0.47	0.16	0.8	3.7	0.32	0.04
PM_1	23.5	37.2	12.92	0.99	17.1	31.9	8.79	0.56
$PM_{2.5}$	30.7	50.6	18.24	1.37	20.9	42.5	11.53	0.81
PM_{10}	38.2	64.6	20.93	2.08	23.6	53.9	12.66	1.07
TSP	39.5	68.5	21.49	2.25	23.8	55.5	12.76	1.09

Table 2. Mean concentrations of 13 PM size fractions (µg m^{-3}) and PM-bound mercury (PBM, pg m^{-3}), organic carbon (OC, µg m^{-3}) and elemental carbon (EC, µg m^{-3}) at two sites in Zabrze.

PM fraction	Zabrze – city center				Zabrze - residential area			
	PM	PBM	OC	EC	PM	PBM	OC	EC
$PM_{0.03-0.06}$	0.3	2.9	0.17	0.04	0.2	2.4	0.13	0.01
$PM_{0.06-0.108}$	1.0	1.5	0.30	0.12	0.6	1.3	0.20	0.03
$PM_{0.108-0.17}$	1.4	3.0	0.54	0.18	0.8	2.0	0.38	0.04
$PM_{0.17-0.26}$	2.1	3.8	0.92	0.19	2.0	3.0	0.81	0.05
$PM_{0.26-0.4}$	3.3	4.5	1.35	0.16	3.1	4.7	1.60	0.09
$PM_{0.4-0.65}$	7.7	10.2	4.40	0.15	5.5	9.6	2.76	0.20
$PM_{0.65-1}$	7.7	11.4	5.24	0.15	5.0	8.9	2.91	0.16
$PM_{1-1.6}$	4.7	8.9	3.99	0.19	2.5	6.6	1.92	0.14
$PM_{1.6-2.5}$	2.6	4.5	1.34	0.19	1.3	3.9	0.83	0.11
$PM_{2.5-4.4}$	4.3	6.1	1.29	0.28	1.7	5.3	0.59	0.14
$PM_{4.4-6.8}$	2.1	4.3	0.80	0.24	0.7	2.5	0.35	0.09
$PM_{6.8-10}$	1.0	3.6	0.59	0.19	0.3	3.6	0.18	0.04
PM_{10-100}	1.3	3.9	0.56	0.17	0.2	1.6	0.11	0.01

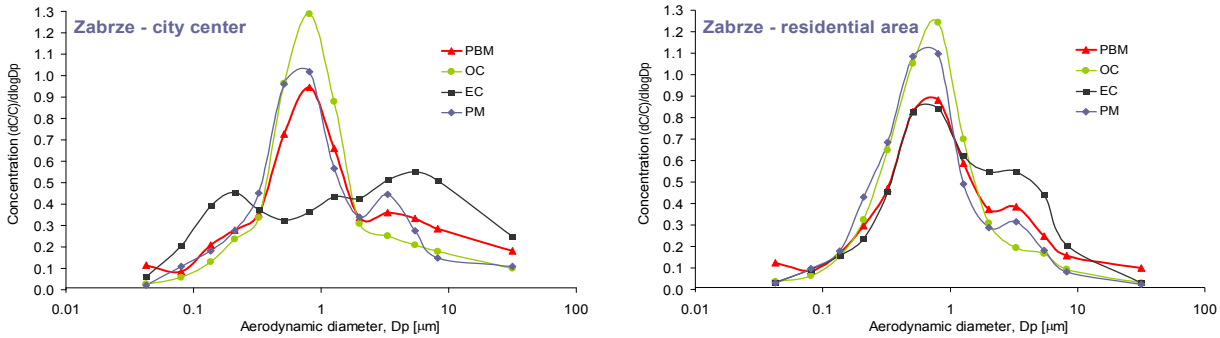

Figure 1. Mass size distribution of PM-bound mercury (PBM, pg m^{-3}), organic carbon (OC, µg m^{-3}) and elemental carbon (EC, µg m^{-3}) at two sites in Zabrze.

Conclusion

The experiment showed that almost entire PBM was inhalable: 97% of the its mass was in PM_{10} at both sites (Table 1). Nearly 83% of PBM was respirable, i.e. was in $PM_{2.5}$, 66% was in PM_1, and 6% in $PM_{0.1}$. The mass size distributions of PBM at both sites were bimodal, like those of PM (Fig. 1). Both density functions have a maximum (mode) in the interval 0.65–0.1 µm of the diameters (D_p) of the primary accumulation particles from combustion processes. The second mode they have in 2.5-4.4 µm (coarse particles).

At the residential site, the distribution of PBM corresponds very well with the distributions of PM-bound OC and EC – PM comes from coal combustion. At the city center, near the crossroads, there was no such agreement (Fig. 1), the PBM mass size distribution having two modes, as at the residential site, and the EC one having three modes, the mode in 0.17–0.26 µm attributable to "fresh" soot from car exhaust. The behavior and correlation of PBM and PM-bound C at the residential site are proper to PM coming from coal combustion. Instead, the EC distribution at the crossroads is visibly distorted by road traffic while the PBM one is not.

References

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