Sampling and characterization of resuspended and respirable road dust

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Abstract

Urban air quality is severely affected by traffic related particulate matter, including direct emissions from exhaust, brake pad, tire wear and road dust resuspended by vehicular motions. Deposited road dust can also be resuspended by wind force or other anthropogenic activities, and overall it may contribute up to 30 % to urban PM_{10}. A mobile resuspended road dust PM_{10} sampler was developed and constructed which simulates the effects of traffic or gusting winds on road surfaces and collects resuspended PM_{1-10} samples in a cyclone separator and PM_1 samples on filters. The sampler was tested by collecting resuspended road dust at kerbside locations in Veszprém, Hungary. The collected PM_1 and PM_{1-10} fractions were analysed by various analytical methods to show the potential of size-selective on-line sample collection combined with the chemical characterization of resuspended road dust. The main constituents of the resuspended road dust were crustal elements, and it was also possible to determine the mineral phase composition of PM_{1-10} dust which is generally not feasible from samples collected on filter substrate. The application of the sampling and analysis methods may facilitate the evaluation of resuspended road dust sources in cities as well as help constrain a better source apportionment of urban PM_{10}.

1. Introduction

Air pollution in cities is a very complex issue, showing strong seasonality and dependence on meteorological factors, sometimes culminating in severe and dangerous smog episodes which require intervention by local authorities. The urban particulate matter with aerodynamic diameter less than 10 μm (PM_{10}) is now identified as one of the most dangerous air pollutants on human health because its size range overlaps with the range of respirable particles. Prolonged exposure to respirable urban PM_{10} has been associated with adverse health effects and linked to an increased risk of respiratory illnesses (Pope, 1996).

Resuspension of road dust is now an established source of urban particulate matter. Fugitive dust from paved and unpaved roads and bare grounds as well as construction and demolition works was shown to be important contributors to both PM_{10} and $PM_{2.5}$ in urban aerosol (Chow and Watson, 2002). A source apportionment study based on elemental composition of particles using Al as a tracer for crustal matter estimated a total contribution of 10 % (m/m) in PM_{10} and 6 % in $PM_{2.5}$ in Hong Kong (Ho et al., 2003). On the other hand, in Mexico City fugitive dust was estimated to account for as much as 54 % (m/m) of PM_{10} (Vega et al., 2001). Its contribution strongly depends on local conditions, including meteorology, road surface, traffic, etc.

In addition, dust particles preserve cumulative signatures of particles that had once been airborne and deposited from the atmosphere at the location of sampling. Its detailed analysis may provide qualitative and quantitative information on the significance of various local and regional aerosol sources. Fugitive dust sources are extremely difficult to measure and quantify in urban air due to their diffuse nature and strong dependence on sampling conditions (Cowherd and Grelinger, 1992; Watson and Chow, 2001).

Detailed source profile studies on this fraction of aerosol that can be used for receptor modeling is known (Ho et al., 2003; Vega et al., 2001; Amato et al., 2010). The mass size distribution of primary particles of fugitive dust is poorly characterized. Scanning electron microscopic examination of PM$_{10}$ particles in Shanghai showed that most of particles were originally released from construction sites, cement plants, vehicle exhaust, coal boilers and steel mills (Li et al., 2003). Such studies typically used the source type "paved road dust" as a collective term for all types of urban dust particles, including freshly emitted or resuspended particles, without regard to their ultimate origin (Schauer et al., 1996).

Sampling of resuspended urban particulate matter has usually been performed by simply sweeping and sieving deposited road dust (Wei et al., 2009; Han et al., 2007; Manno et al., 2006; Ho et al., 2003). In a few studies the collected bulk samples were resuspended in the laboratory and the size-distribution of the particles was determined (Zhao et al., 2006; Chow et al., 2004). These procedures and sample treatments were affected by the loss of fine particles owing to the difficulties of collecting all deposited material and to the electrostatic adhesion of particles to brush hairs and sieve meshes. A recent study has shown that aerosol particles can be quantitatively resuspended from road dust using a specific sampling device (Amato et al., 2009). The objective of this study is to develop and test a mobile sampler that simulates the effect of strong winds and heavy traffic and on-line collects the resuspended PM$_{10}$ particles. Furthermore the potential of various analytical methods are evaluated in the use of the samples for source profiling of resuspended road dust in source apportionment of urban PM$_{10}$.

2. Material and methods

2.1 Resuspension and sampling unit

This work involved the development and construction of a mobile resuspended road dust PM$_{10}$ sampler which induces resuspension and collects particles on-line directly from road surfaces (see Fig. 1). A rectangular stainless-steel hood (length: 600 mm, width: 400 mm, height: 170 mm) was fixed to the front of a laboratory cart 0.5 cm above the road surface. A leaf blower (Makita UB1101, 600W) was connected to the

97 hood through two facing nozzles at an angle of 65° (of 30° correlates to the surface)

98 via a split flexible hose. This setup was designed to induce turbulence inside the

99 hood which can resuspend a part of the road dust from solid surfaces. In this

100 configuration the system is not air-tight, but there is a constant outflow from under

101 the hood inside which the mass concentration of resuspended road dust is much

102 higher (by a factor of 1000) than that of PM_{10} in ambient air. The air velocity was

103 measured at the nozzles with an anemometer, and was found to be ~65 km hr^{-1}. The

104 hood was connected to the duct system with a stainless steel tube (length: 200 mm,

105 diameter: 100 mm). The duct system (length: 1.8 m, internal diameter: 30 mm) was

106 designed for an air velocity in the vertical duct section at which particles larger than

107 ~110 μm aerodynamic diameter can effectively settle out by gravitational settling and

108 do not overload the PM_{10} sampling head of the sampler. The duct was connected to

109 an alumina housing (height: 350 mm, diameter: 350 mm) containing the R&P PM_{10}

110 inlet. This housing was composed of two parts to facilitate cleaning. The height of the

111 bottom part was 100 mm and that of the upper one was 250 mm, the diameter of this

112 housing was 350 mm. During sampling the two parts was closed hermetically, the
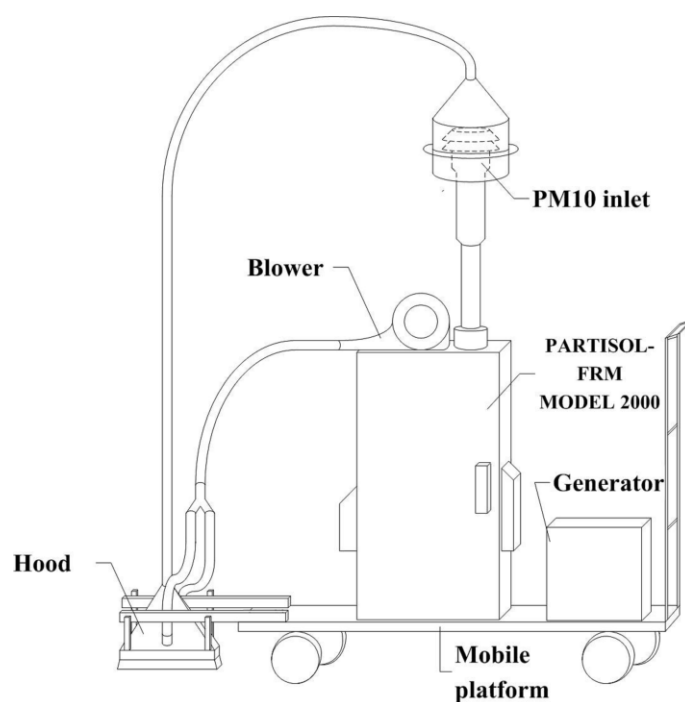
113 volume of the housing was approximately 24.5 dm^3.

114

Fig. 1. The mobile resuspended PM_{10} sampling unit.

118　A PARTISOL-FRM MODEL 2000 sampler (operating at the flow rate of 16.7 l min^{-1})
119　was mounted on a mobile sampling cart. This sampler collected resuspended PM_{1-10}
120　samples in a cyclone separator and PM_1 samples on filters. The sampling unit was
121　powered with a portable electrical power generator (Honda EU10i), also mounted on
122　the platform. The mobile sampling unit has been successfully deployed on the site of
123　the catastrophic red mud spillage near Ajka- Kolontár, Hungary (Gelencsér et al.,
124　2011).

125

2.2 Sample transfer and gravimetric determination

127　The PM_1 fraction was collected on 47 mm diameter Whatman quartz filter, and
128　before and after sampling filters were weighted with a microbalance (Sartorius, 10 μg
129　sensitivity). The PM_{1-10} fraction was deposited in the sharp-cut cyclone-separator of
130　the PARTISOL sampler. The collected dust samples were transferred with a PTFE-
131　coated spatula into pre-weighted clean vials. Then the vials were weighted again
132　with a microbalance. The total mass of the PM_{1-10} fraction was determined by
133　difference. It should be noted that though sample collection from the surface is not
134　quantitative, mass concentration data above the surface during the sampling can be
135　derived for comparative purposes. The resuspended road dust samples were tagged
136　and stored in the freezer until analysis. The collected PM_{1-10} fractions were analysed
137　by various analytical methods to establish chemical composition, to identify major
138　source types and to assess the potential contribution of major sources to deposited
139　dust.

140

2.3 Chemical analyses

142　The direct determination of phase composition of particulate matter has not generally
143　been available in ambient aerosol studies due to limited sample size and the
144　presence of a filter matrix. However, quantification of phase composition would be an
145　invaluable supplement to source apportionment studies of specific aerosol types
146　such as resuspended road dust. The X-ray diffraction (XRD) analyses were carried
147　out with a Philips PW 3710 type diffractometer equipped with a PW 3020 vertical
148　goniometer and curved graphite diffracted beam monochromator. The radiation
149　applied was CuKα from a broad focus Cu tube, operating at 50 kV and 40 mA. The

samples were measured in continuous scan mode with $0.02\,^{\circ}\,sec^{-1}$ scanning speed. Each small powder sample (approximately 7 mg) was deposited on a glass plate from a slurry of the sample in isopropyl alcohol (Bish and Post, 1989). The quantitative determination was carried out with Rietveld analysis which is a full-pattern fitting method. In this method the measured diffraction profile and the calculated profile are compared, and the difference is minimized. Crystal structure data, such as atom positions are necessary to the standard Rietveld refinement. In addition the scale factors calculated for the mixture of phases are proportional to weight fractions.

Due to the limited amounts of resuspended road dust samples particle morphologies were studied and elemental composition (of elements with Z>5) were determined by environmental scanning electron microscopy (ESEM, Philips XL30) with an attached EDAX energy-dispersive X-ray spectrometer (EDS). ESEM was operated at 20 kV accelerating voltage in low-vacuum environmental mode due to the non-conductive character of the samples. PM_{1-10} powder samples were sprinkled on cylindrical Al stubs covered by double coated conductive carbon tape. Determination of mean elemental composition (except C) was performed on 3 different areas (200×200 μm) of each prepared sample. Secondary electron (SE) images of hundreds of particles in each PM_{1-10} fraction were taken to characterize of particle sizes and morphologies.

The total carbon (TC) concentration of PM_{1-10} samples were analysed by high-temperature catalytic oxidation, using Zellweger Astro TOC 2100 total carbon analyzer with NDIR detector. The TC was determined by catalytic burning at $680\,^{\circ}C$ in oxygen followed by non-dispersive infrared detection of the evolved CO_2. Approximately 0.5 mg of bulk dust samples were oxidized in the combustion boat. Calibration of the instrument was performed with reagent-grade potassium hydrogen phthalate (VWR International) dissolved in high-purity water (MilliQ).

The water-soluble inorganic ions (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, NO_3^- and SO_4^{2-}) were measured by Dionex DX300 gradient chromatographic system that consists of a CHA-6 high pressure chromatographic module, Dionex EDM eluent degas module and gradient pump equipped with a conductivity detector CDM-II. Separations were carried out by a Dionex IonPac AS12A column for anions and a Dionex IonPac

CS12A column for cations. The conductivity of the eluent was suppressed by a Dionex CSRS 300 4 mm suppressor. Approximately 1 mg samples were extracted with 1 ml high-purity water. The detection limit of each ion was 10 ppb.

A series of 16 polycyclic aromatic hydrocarbons (PAHs) regulated by the US Environmental Protection Agency (US-EPA) were analysed. PAHs were determined by liquid chromatography with Jasco PU-980 pump, Jasco LG-980-02 gradient unit and Waters 470 scanning fluorescence detector. Separations were carried out by a LiChrospher PAH 5 µm column with RP18 silica gel charge, and its temperature was held at 35 °C with a Waters thermostat. Approximately 6 mg dust samples were extracted with 1 ml of dichloromethane:methanol (80:20) solvent mixture. Extraction was performed in an ultrasonic bath for 20 minutes. The extracts were filtered by 0.22 Gv filters. The injection volume was 20 µl. The calibration was performed with TCL polynuclear aromatic hydrocarbons mix (SUPELCO) dissolved in acetonitrile:methanol (9:1) solvent. The standard solution containing the 16 EPA priority pollutant PAHs: naphthalene (Nap), acenaphthylene (Acy), acenaphthene (Ace), fluorine (Fl), phenanthrene (Phe), anthracene (Ant), fluoranthene (Fla), pyrene (Pyr), benz[a]anthracene (BaA), chrysene (Chry), benzo[b]fluoranthene (BbF), benzo[k]fluoranthene (BkF), benzo[a]pyrene (BaP), ideno[1,2,3-cd]pyrene (IndP), dibenz[a,h]anthracene (dBaAnt) and benzo[g,h,i]perylene (BghiPer). 15 PAHs (exception is acenaphthylene) were detected with fluorescence detector.

The TC and PAHs concentrations of PM_1 fractions on quartz fiber filters were also determined with the above methods. TC concentrations were analyzed from filter spots of 10 mm in diameter which were cut with a special puncher and were oxidized directly in the combustion boat. PAHs concentrations were measured from the remaining filter samples. Other measurements were not carried out due to the limited sample size and the presence of the filter matrix.

3. Testing

3.1 Sampling

The sampling unit was tested by collecting resuspended particulate matter at three kerbside locations in Veszprém, Hungary. Veszprém lies approximately 110

214 kilometers far from the capital of Hungary, Budapest. The city is lying in the embrace
215 of Lake Balaton and the Bakony Hills, on both sides of the Séd creek. Veszprém has
216 about 60 thousands inhabitants, its climate is continental. The daily average
217 temperature is 20 ºC in summer and −1 ºC in winter.

218 Each sampling involved collection of resuspended road dust from a sampling area of
219 about 840 m^2. The samples were collected on the sidewalks ~ 2 m from the roads for
220 a period of 2 hours each. The sampling was carried out on three consecutive days
221 between 22 and 24 September 2010. The sampling locations were characterized
222 with high traffic of passenger cars and busses, but heavy-duty trucks were not
223 allowed. The speed limit is 50 km hr^{-1}.

224 The meteorological and air quality parameters before and during sampling days were
225 recorded by the local meteorological station of Veszprém and by the Hungarian Air
226 Quality Monitoring Network. During this period the daily mean temperature varied
227 between 12 and 18 °C. The sampling took place three days after a rainy period
228 between 16 and 19 September, under generally dry conditions. On the days of
229 sampling the daily mean PM_{10} concentrations were 28.4, 29.2 µg m^{-3} and absent
230 data on 24 September, and the NO_x concentrations were 62.6, 60.7 and 43.1 µg m^{-3}.

231

232 ## 3.2 Mass proportion of resuspended road dust

233 Even if the collection of resuspended PM_{10} is not quantitative, a surface load of
234 resuspended PM_{10} can be estimated from the measured data by taking into account
235 the flow rate of the blower and that of the PM_{10} sampler. The estimated surface load
236 of PM_{10} was found to be 3.4−4.9 mg m^{-2} at the three sites. This value compares well
237 with surface loads estimated from measured emissions caused by passing vehicles
238 (0.3−3 mg m^{-2}) (Etyemezian et al., 2003). The absolute mass concentrations of the
239 PM_{1-10} and PM_1 fractions inside the sampling hood were determined by weighted
240 masses on filters and in vials. The mass concentration of the PM_{1-10} was 15.4−19.6
241 mg m^{-3} and of the PM_1 fraction was 0.2−2.7 mg m^{-3}.

242

243 Table 1. Sampling locations and the absolute mass concentrations of the collected
244 PM_{1-10} and PM_1 fractions, and the surface loads of resuspended PM_{10}.

Code	Location	GPS	Date	Absolute mass concentrations		PM_{1-10} [mg m^{-3}]	PM_1 [mg m^{-3}]	Surface loads of PM_{10} [mg m^{-2}]
				PM_{1-10} [mg]	PM_1 [mg]			
1	Egyetem Str.	47°05'13"/17°54'30"	22 Sept.	36.35	5.12	18.2	2.56	4.54
2	Cholnoky Str.	47°05'25"/17°55'27"	23 Sept.	39.19	5.36	19.6	2.68	4.88
3	Jutasi Str.	47°06'20"/17°54'42"	24 Sept.	30.75	0.46	15.4	0.23	3.42

245

246 The PM_1 fraction constituted on average 9.3 % of the PM_{10} fraction in the

247 resuspended road dust which compares well with the mass ratio of fine (PM$_{2.5}$) to

248 total (PM_{10}) particles found in soil and paved road dust (10 −30 %) (Ho et al., 2003).

249 In addition the particulate matter with aerodynamic diameter less than 1 μm (PM$_1$)

250 was sampled directly and was much less subject to losses during sampling.

251

252 ## 3.3 Phase composition

253 In addition to source profiling based on elemental composition the direct

254 determination of mineral phase composition is also feasible from resuspended bulk

255 PM_{1-10} road dust samples. Similarly to the quantification of oxygen, this is also not

256 available on dust samples collected on filter substrates. The mineral phase

257 composition could, on one hand, be used to cross-check mass balance calculations

258 based on elemental compositions. But more importantly, it can be used in the source

259 identification of resuspended road dust itself, as thermally altered phases can be

260 directly identified and quantified by this method. Moreover, by comparing mineral

261 phase compositions of resuspended native soils in the areas, building materials

262 resuspended road dust it may also be possible to estimate the relative contribution of

263 demolition and construction works to the resuspended road dust concentrations in

264 cities.

265 In the resuspended bulk PM$_{1-10}$ road dust samples the major mineral phases

266 identified were dolomite [$CaMg(CO_3)_2$], calcite [$CaCO_3$], clinochlore

267 [$(Mg,Fe)_6(Si,Al)_4O_{10}(OH)_8$], quartz [$SiO_2$], muscovite [$KAl_2Si_3AlO_{10}(OH)_2$], albite

268   [NaAlSi$_3$O$_8$], orthoclase [KAlSi $_3$O$_8$] and gypsum [CaSO $_4$·2H$_2$O], in the mass ratios

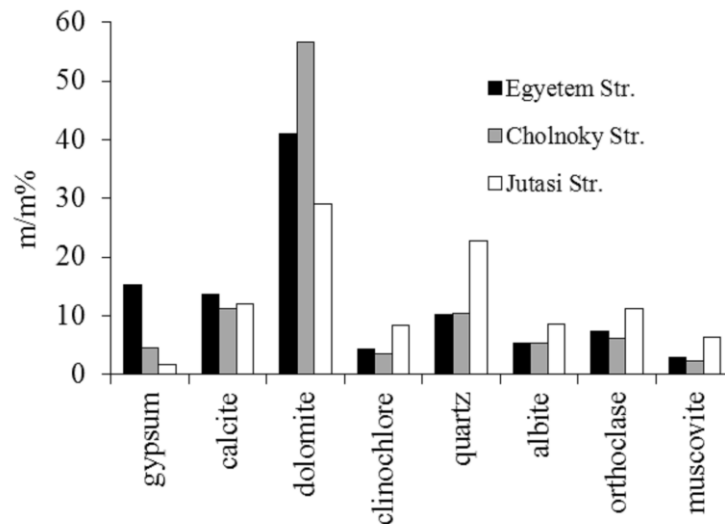269   shown in Fig. 2.

270

271

272   Fig. 2. The mineral phase composition of resuspended road dust (m/m%).

273

274   The main mineral phase in the resuspended road dust is dolomite which forms the

275   rock bed in the entire region around Veszprém. There are dolom   ite mines in

276   operation upwind the town of Veszprém and all the unpaved roads in the region are

277   covered with ground dolomite. It is therefore not surprising that the predominant

278   mineral phase in the resuspended road dust is dolomite. Calcite, quartz and gypsum

279   are much less related to the phase composition of local soils, they mostly come from

280   industry, and building activities such as construction and demolition works. The other

281   mineral phases (clinochlore, albite, orthoclase and muscovite) in lower amounts

282   indicate the crustal origin, originate from the regional soils or abrasion of surfaces.

283

284   ## 3.4 Morphologies of individual particles

285   The morphologies of individual particles in the PM $_{1-10}$ fraction are similar in each

286   sample as observed in the SEM. Most of the particles have irregular shape, their

287   geometric sizes vary between 1 and 5 µm. The smallest particles form fluffy

288   aggregates and, the larger ones also appear as loose aggregates. There are some

289   individual grains which have nearly euhedral crystal shape. Although the original

290   crystal shape has been eroded by the weathering process as it is manifested in the

291 rounded edges and growth terraces some crystals have rhombohedral shape. This
292 shape is typical for carbonate minerals which form the main mineral phase of the
293 resuspended PM_{1-10} based on the XRD measurements.
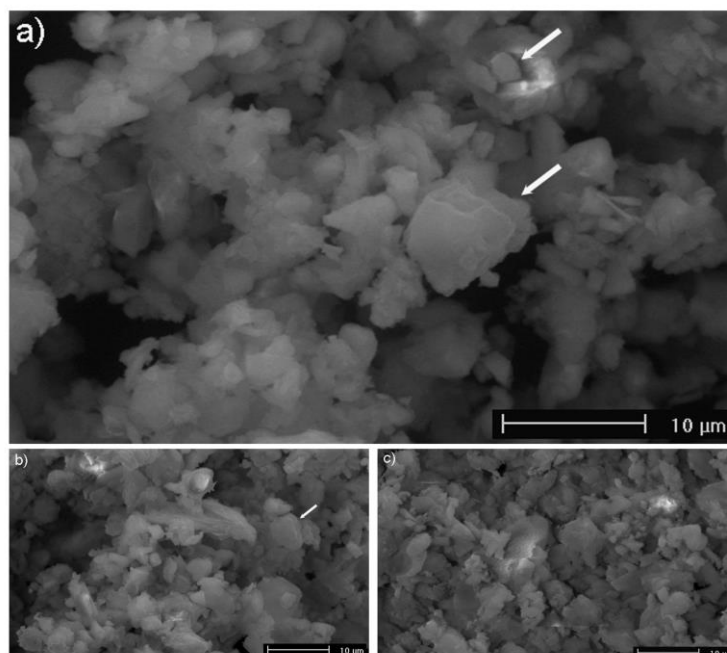
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295
296 Fig. 3. SEM images of the PM $_{1-10}$ fraction of resuspended road dust. (a) sample 1,
297 (b) sample 2, (c) sample 3. The particles form loose aggregates. White arrows
298 indicate euhedral crystals with rounded edges.

299

3.5 Chemical composition

301 Due to the limited sample amount the elemental composition of resuspended PM $_{1-10}$
302 was determined by EDS and TC analyses. The mass concentrations of the identified
303 elements are given in units of mg g^{-1} (in Table 2). The main constituents of the
304 PM_{1-10} fraction were O, Si, Ca, C, Al, Mg, Fe, S, K and Na. Crustal elements such as
305 Si, Al, Ca, Fe have been identified in other studies   (Vega et al., 2001; Zhao et al.,
306 2006) as important constituents of the resuspended dust, but collection and analyses
307 of bulk dust samples offers the possibility of measuring concentrations of oxygen
308 which is generally not feasible in the analyses of filter samples. Direct measurement
309 of mass concentration of oxygen can be a useful complement of mass balance
310 calculations necessary for source apportionment studies. Furthermore, the sensitivity
311 of the method and the lack of filter matrix allow the determination of less abundant

312   elements. For example, in the resuspended PM 1–10 samples P, Cl and Ti were also

313   quantified. Titanium is known to result from resuspension of soil and road pavement

314   erosion (Amato et al., 2009; Guo et al., 2009). The contribution of phosphorous in

315   the resuspended PM 1–10 was significant compared to its mass proportion in the

316   PM2–10 fraction of urban aerosol (0.08 m/m%)   (Salma et al., 2002). It might be

317   possible that phosphorous originate from microbiological activities taking place in the

318   deposited dust and thus might serve as a tracer for resuspended   dust. Such

319   hypotheses, however, require further targeted studies and are beyond the scope of

320   the present study. It should be pointed out that the suggested methods of sample

321   collection and analyses open the possibility of better source profiling of resuspended

322   road dust component for urban PM_{10} studies.

323   The average TC concentration of PM 1 fraction was 114.4 mg g^{-1} (standard deviation

324   14.68 mg g^{-1}) which may be influenced by soot particles from vehicular emission.

325   As part of routine aerosol analyses water-soluble inorganic ions can also be

326   determined in the bulk PM 1–10 resuspended road dust samples. This feature is also

327   available for PM_{10} samples collected on filter substrate. Note that the analyses of the

328   bulk samples yields concentrations in units of mg g^{-1} which allows source profiles to

329   be established. It is generally not expected that water-soluble ions would be

330   predominant components of resuspended road dust. The concentrations of the

331   water-soluble inorganic ions in PM1–10 fractions are shown in Table 2.

332   Similarly, as part of the routine aerosol analyses, PAHs can also be determined in

333   the resuspended bulk PM1–10 and PM1 fractions on filter. The concentrations of PAHs

334   are given in units of µg g^{-1} (in Table 2). The average mass concentration in the PM 1–

335   10 fraction was 2.38 µg g^{-1} (standard deviation 1.02 µg g^{-1}), and in the PM 1 fraction

336   was 16.83 µg g^{-1} (standard deviation 16.34 µg g^{-1}). It may be expected that as a

337   result of cumulative deposition and the proximity of tailpipe emission sources, PAHs

338   that are characteristic of vehicular emission (Diesel or gasoline) will be enriched in

339   the PM 1–10 fraction of road dust relative to that in the coarse fraction of urban

340   particulate matter. This may increase the health risk associated with the inhalation of

341   resuspended road dust, but may also provide a tool for fingerprinting resuspended

342   road dust in the coarse fraction of urban PM_{10}.

343

344

345 Table 2. Chemical composition of PM $_{1-10}$ and PM $_1$ fractions of resuspended road

346 dust

		PM$_{1-10}$			PM$_1$		
		Egyetem Str.	Cholnoky Str.	Jutasi Str.	Egyetem Str.	Cholnoky Str.	Jutasi Str.
	C	83.9	74.3	94.1	122	124	97.5
	O	402	409	377			
	Na	13.3	12.7	12.2			
	Mg	53.1	68.1	38.2			
	Al	62.1	59.8	82.1			
	Si	138	134	189			
	P	7.42	6.48	6.94			
	S	19.1	10.0	9.30			
	Cl	3.76	3.33	4.02			
$mg\ g^{-1}$	K	16.6	15.4	21.5			
	Ca	163	173	115			
	Ti	4.09	3.46	5.13			
	Fe	34.0	31.4	45.6			
	Na^+	0.05	0.23	0.18			
	NH_4^+	<LOD	<LOD	<LOD			
	K^+	1.06	0.64	0.95			
	Mg^{2+}	0.84	0.84	0.77			
	Ca^{2+}	18.1	11.9	12.2			
	Cl^-	0.31	0.70	0.31			
	NO_3^-	0.06	0.06	0.32			
	SO_4^{2-}	30.7	8.03	3.13			
	Nap	0.29	<LOQ	<LOQ	0.00	0.04	<LOQ
	Ace	<LOQ	<LOQ	<LOQ	1.40	<LOD	<LOQ
	Fl	0.10	0.08	0.11	0.07	0.07	0.24
	Phe	1.07	0.47	0.92	1.44	1.31	4.74
	Ant	0.02	0.04	0.02	0.25	0.06	0.63
	Fla	0.48	0.25	0.24	1.51	0.86	1.66
$\mu g\ g^{-1}$	Pyr	0.51	<LOD	<LOQ	1.69	1.34	7.22
	BaA	0.05	<LOQ	<LOQ	<LOD	0.06	<LOD
	Chry	0.27	0.09	0.24	0.78	0.38	3.09
	BbF	0.23	0.12	0.20	0.40	0.34	0.37
	BkF	0.08	0.04	0.06	0.29	0.11	0.88
	BaP	0.09	0.08	0.10	0.36	0.25	1.28
	dBaAnt	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD
	BghiPer	0.17	0.21	0.20	0.45	0.39	0.80
	IndP	0.12	0.08	0.10	0.37	0.24	0.73
	ΣPAHs	3.48	1.46	2.20	9.40	5.53	35.57

LOD: Limit of Detection
LOQ: Limit of Quantification

347

4. CONCLUSIONS

A novel method for direct sampling of resuspended and respirable urban particulate matter has been developed and tested successfully. Although the collection method is not designed to be quantitative, it simulates the possible effects of environmental factors on road dust resuspension. Therefore it is capable of producing a representative aliquot of resuspended PM_{10} in two size bins (PM_{1-10} and PM_1). The use of sharp-cut cyclone separator allows the collection of bulk particulate matter in the PM_{1-10} fraction. The availability of bulk PM_{1-10} facilitates the application of low-cost analytical methods to determine the elemental, chemical and phase composition of resuspended particulate matter, as it has been demonstrated in this study.

Contrary to other indirect methods of resuspended road dust characterization, such as brushing, sieving or laboratory resuspension of collected bulk particulate matter, the methodology presented may offer unbiased collection and characterization of resuspended PM_{10}. The determination of the chemical and phase composition of the samples offers the possibility of more reliable source apportionment of resuspended urban PM_{10} that poses a potential health risk for the population. Furthermore, chemical source profiling of this poorly characterized fugitive source type is also possible by this methodology. Chemical source profiles are indispensable for reliable source apportionment studies of urban PM_{10} that serve as input to air quality management in cities. In addition, planned developments in automobile industry aiming at reducing non-exhaust (fugitive) emissions from vehicles may also benefit from the application of the proposed methodology.

VITAE

Beatrix Jancsek-*Turóczi* began her PhD in environmental science in 2009 in the Institute of Environmental Sciences at the University of Pannonia. Her research interest is sources and health effects of urban particulate matter.
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