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Supplement of

Fossil fuel combustion, biomass burning and biogenic sources of fine carbonaceous aerosol in the Carpathian Basin

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Table S1. Mean apportionment multiplication factors of the coupled radiocarbon-levoglucosan marker model with SDs for regional background in the Carpathian Basin, suburban area and city centre of Budapest for different months of seasons.

Factor	Site type	October	January	April	July
f_1 (%)	Region	69±3	75±3	63±13	74±9
	Suburb	68±6	76±7	50±6	57±11
	Centre	76±10	74±2	50±9	58±7
f_2 (%)	Region	7.6±1.3	14±1	1.6±0.5	0.41±0.15
	Suburb	8.3±1.7	15±2	3.5±1.1	0.50±0.24
	Centre	6.0±1.0	13±1	2.7±1.1	0.61±0.18
f_3 (%)	Region	49±9	93±6	10±3	2.4±1.0
	Suburb	53±12	97±16	21±7	2.9±1.5
	Centre	38±7	90±8	16±7	3.6±1.1
f_4 (%)	Region	28±14	5.3±2.4	35±13	24±14
	Suburb	14±11	6.8±2.0	36±8	33±5
	Centre	29±17	19±4	45±12	31±6

Table S2. Median atmospheric concentrations of SO₂, NO, NO₂, CO, O₃ and PM₁₀ mass for regional background in the Carpathian Basin, suburban area and city centre of Budapest for the different months of seasons.

Pollutant	Site type	October	January	April	July
SO ₂ (µg m ⁻³)	Region	0.44	NA	NA	NA
	Suburb	2.2	2.0	1.35	1.50
	Centre	7.0	5.3	4.7	2.7
NO (µg m ⁻³)	Region	NA	NA	NA	NA
	Suburb	8.4	4.7	1.40	1.05
	Centre	74	51	17.3	10.6
NO ₂ (µg m ⁻³)	Region	2.9	NA	NA	NA
	Suburb	36	25	19.3	12.8
	Centre	52	37	57	31
CO (mg m ⁻³)	Region	NA	NA	NA	NA
	Suburb	0.50	0.60	0.78	0.69
	Centre	0.69	0.56	0.61	0.33
O ₃ (µg m ⁻³)	Region	NA	37	103	92
	Suburb	12.4	15.5	67	74
	Centre	3.4	2.7	38	55
PM ₁₀ mass (µg m ⁻³)	Region	14.5	NA	NA	NA
	Suburb	30	29	39	21
	Centre	38	41	42	23

NA – not available.

Table S3. Mean atmospheric concentrations and SDs of SO₂, NO, NO₂, CO, O₃ and PM₁₀ mass for regional background in the Carpathian Basin, suburban area and city centre of Budapest for different months of seasons.

Pollutant	Site type	October	January	April	July
SO ₂ (µg m ⁻³)	Region	0.67±0.38	NA	NA	NA
	Suburb	2.4±0.5	2.1±0.7	1.35±0.60	1.55±0.35
	Centre	7.0±0.2	5.8±0.9	4.7±0.8	2.7±0.1
NO (µg m ⁻³)	Region	NA	NA	NA	NA
	Suburb	12.7±10.7	11.1±10.1	1.44±0.75	1.08±0.46
	Centre	75±16	50±17	17.6±3.2	10.2±2.3
NO ₂ (µg m ⁻³)	Region	3.1±1.4	NA	NA	NA
	Suburb	36±20	31±12	18.9±8.7	14.9±7.3
	Centre	50±8	39±6	52±11	32±7
CO (mg m ⁻³)	Region	NA	NA	NA	NA
	Suburb	0.48±0.20	0.66±0.18	0.82±0.13	0.61±0.17
	Centre	0.68±0.09	0.60±0.09	0.61±0.07	0.34±0.06
O ₃ (µg m ⁻³)	Region	NA	41±21	96±17	90±11
	Suburb	21±18	16.7±13.1	67±12	71±13
	Centre	4.0±2.0	3.5±2.1	40±11	56±9
PM ₁₀ mass (µg m ⁻³)	Region	17.4±12.7	NA	NA	NA
	Suburb	36±25	30±15	35±11	24±6
	Centre	40±13	40±12	42±9	27±7

NA – not available.

Table S4. Mean air temperature (T), relative humidity (RH), wind speed (WS) and daily maximum global solar radiation (GRad_{max}) with SDs for regional background in the Carpathian Basin, suburban area and city centre of Budapest during the aerosol sampling campaign for different months of seasons.

Property	Site type	October	January	April	July
T (°C)	Region	8.4±1.9	1.8±2.9	17.1±2.6	23±2
	Suburb	10.0±2.2	2.5±3.3	19.0±2.0	24±2
	Centre	12.9±1.9	2.5±3.5	19.9±1.0	24±2
RH (%)	Region	88±10	89±10	64±8	78±9
	Suburb	75±11	79±8	48±9	56±8
	Centre	79±4	82±4	49±9	64±9
WS (m s ⁻¹)	Region	1.61±1.14	1.52±0.71	1.45±0.57	1.55±0.72
	Suburb	1.64±1.10	1.63±0.49	1.27±0.23	1.32±0.68
	Centre	1.82±0.84	2.1±0.4	2.5±0.5	3.9±1.7
GRad_{max} (kW m ⁻²)	Region	NA	NA	NA	NA
	Suburb	0.31±0.15	0.186±0.106	0.77±0.09	0.79±0.11
	Centre	NA	NA	0.74±0.11	0.76±0.15

NA – not available

The differences in the mean WS can be explained by non-equal heights of the meteorological sensors (3 m above the ground in the regional background and at the suburban area, and 12 m above the street level in the city centre).

Table S5. Mean atmospheric concentrations and SDs of PM_{2.5} mass, elemental carbon (EC), organic carbon (OC), water-soluble organic carbon (WSOC), levoglucosan (LVG), mannosan (MAN), galactosan (GAN), fraction of contemporary total carbon (f_c), K, Ni and Pb for regional background in the Carpathian Basin, suburban area and city centre of Budapest for different months of seasons.

Constituent	Site type	October	January	April	July
PM _{2.5} mass ($\mu\text{g m}^{-3}$)	Region	16.3±8.3	18.4±6.4	9.7±2.7	10.5±1.7
	Suburb	24±13	25±9	10.4±2.1	11.6±2.8
	Centre	29±11	22±7	13.5±3.1	8.8±1.6
EC ($\mu\text{g m}^{-3}$)	Region	0.41±0.24	0.37±0.13	0.21±0.06	0.131±0.043
	Suburb	0.53±0.30	0.73±0.26	0.51±0.19	0.41±0.16
	Centre	1.08±0.37	0.77±0.22	0.84±0.22	0.40±0.10
OC ($\mu\text{g m}^{-3}$)	Region	3.0±1.8	3.4±1.5	2.1±0.5	2.3±0.4
	Suburb	4.9±3.2	5.4±2.4	2.4±0.5	2.7±0.4
	Centre	6.4±1.9	4.1±1.1	2.8±0.8	2.6±0.4
WSOC ($\mu\text{g m}^{-3}$)	Region	2.1±1.4	2.1±1.0	1.13±0.30	1.62±0.29
	Suburb	2.6±1.7	3.4±1.5	1.27±0.34	2.0±0.3
	Centre	2.8±1.4	2.6±0.7	1.61±0.53	2.0±0.4
LVG ($\mu\text{g m}^{-3}$)	Region	0.189±0.134	0.44±0.21	0.0020±0.0013	0.0081±0.0022
	Suburb	0.34±0.23	0.74±0.44	0.048±0.029	0.0151±0.0100
	Centre	0.38±0.06	0.49±0.15	0.049±0.024	0.0113±0.0027
MAN (ng m^{-3})	Region	19.2±5.7	24±14	2.6±0.2	<1.2
	Suburb	32±23	46±25	3.4±1.7	<1.2
	Centre	29±8	23±7	5.5±2.6	<1.2
GAN (ng m^{-3})	Region	NA	11.9±6.0	1.27±0.25	<0.5
	Suburb	14.1±10.1	22±11	1.47±0.84	<0.5
	Centre	12.3±2.7	14.1±3.9	1.32±0.35	<0.5
f_c (%)	Region	69±3	74±3	63±13	74±9
	Suburb	68±6	76±7	50±6	57±11
	Centre	76±6	74±2	50±9	59±7
K ($\mu\text{g m}^{-3}$)	Region	0.188±0.071	0.26±0.09	0.107±0.043	0.081±0.003
	Suburb	0.22±0.11	0.28±0.14	0.105±0.031	0.075±0.016
	Centre	0.27±0.07	0.28±0.05	0.112±0.031	0.057±0.013
Ni (ng m^{-3})	Region	1.01±0.63	0.71±0.13	1.31±0.32	1.23±0.48
	Suburb	0.97±0.30	0.98±0.59	1.26±0.21	1.35±0.54
	Centre	1.25±0.36	0.86±0.47	1.60±0.23	1.08±0.13
Pb (ng m^{-3})	Region	3.9±0.9	4.1±2.4	3.5±1.9	3.9±3.0
	Suburb	6.4±3.0	7.7±3.9	4.8±1.8	4.5±2.9
	Centre	6.7±1.6	5.5±2.5	5.2±1.9	2.4±1.5

NA – not available.

Table S6. Coefficients of correlation between EC_{FF}, OC_{FF}, EC_{BB}, OC_{BB} and OC_{BIO} on the one side and K, NO, and *T* on the other side for regional background in the Carpathian Basin, suburban area and city centre of Budapest.

Variable (unit)	Site type	EC _{FF} ($\mu\text{g m}^{-3}$)	OC _{FF} ($\mu\text{g m}^{-3}$)	EC _{BB} ($\mu\text{g m}^{-3}$)	OC _{BB} ($\mu\text{g m}^{-3}$)	OC _{BIO} ($\mu\text{g m}^{-3}$)
K ($\mu\text{g m}^{-3}$)	Region	0.02	0.73	0.95	0.95	-0.26
	Suburb	-0.69	0.51	0.90	0.91	0.20
	Centre	-0.22	0.44	0.86	0.86	0.20
NO ($\mu\text{g m}^{-3}$)	Region	NA	NA	NA	NA	NA
	Suburb	-0.36	0.93	0.60	0.60	0.42
	Centre	-0.17	0.39	0.76	0.77	0.44
<i>T</i> (K)	Region	-0.37	-0.58	-0.87	-0.85	0.60
	Suburb	0.59	-0.24	-0.85	-0.87	0.24
	Centre	0.53	-0.08	-0.79	-0.80	0.34

Table S7. Mean contributions with SDs of fossil fuel (FF) combustion, biomass burning (BB), biogenic sources (Bio) and unaccounted part (UnA) to the PM_{2.5} mass in % as rough estimates for regional background in the Carpathian Basin, suburban area and city centre of Budapest for different months of seasons.

Environment	Source	October	January	April	July
Regional background	FF	12±3	8±2	13±6	8±3
	BB	14±3	21±3	3±1	<2
	Bio	14±5	<2	23±5	24±4
	UnA	60±8	70±4	61±8	67±3
Suburban area	FF	14±5	8±3	20±5	15±4
	BB	16±6	23±3	5±3	<2
	Bio	13±5	3±2	16±4	24±3
	UnA	58±13	67±4	59±9	61±5
City centre	FF	9±5	9±2	18±6	20±4
	BB	11±2	22±4	4±2	<2
	Bio	16±3	3±1	18±6	31±6
	UnA	63±3	67±4	60±8	48±6