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Supplement of

Particle and VOC emission factor measurements for anthropogenic sources in West Africa

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Figure S1: Locations of field EFs measurements

Figure S2: Different stoves used for charcoal, wood cooking fire and charcoal making kiln

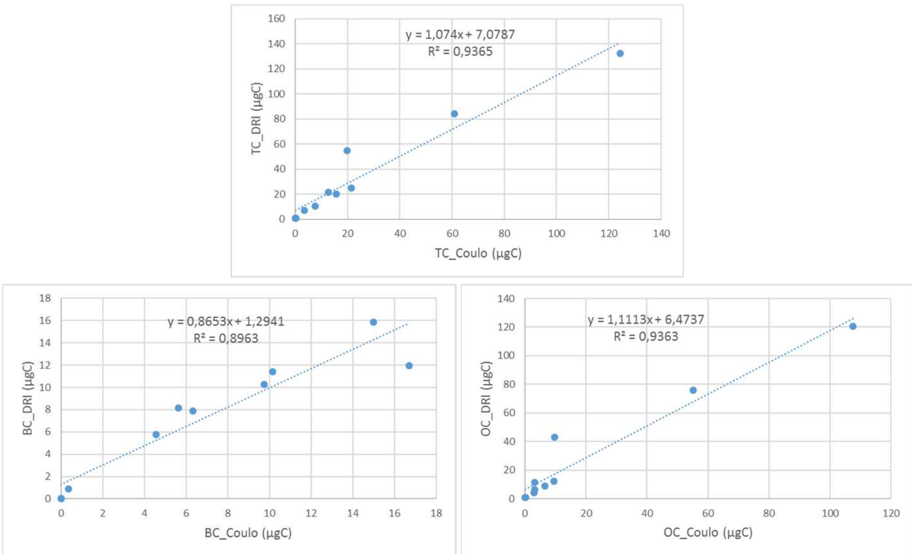

Figure S3: linear regression analysis of each carbonaceous particle values obtained for thermal (coulo) and thermo-optical (DRI) methods

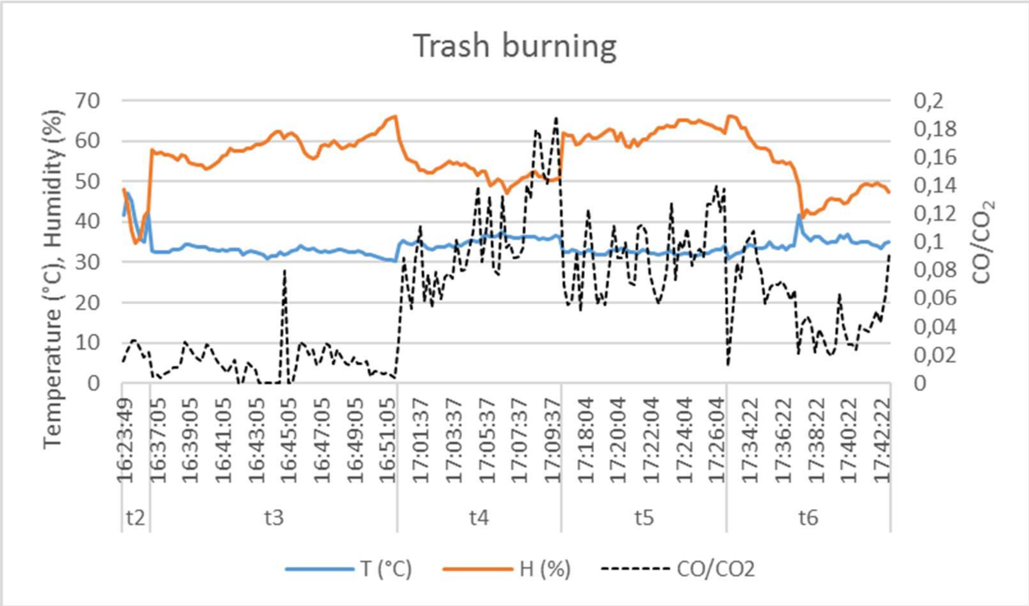

Figure S4: Trash combustion characteristics

VOC uncertainties and detection limits

The reproducibility of the method has been evaluated by sampling several cartridges. Details of the test to evaluate the influence of storage conditions are given in Detournay et al (2011). During this study half of the samples were analysed immediately after sampling, while the other half was stored during 30 days before analysis. The results showed excellent relative standard deviations (RSD) for aromatic compounds and alkanes (1%); and satisfying results were found for terpenes (5%) and oxygenated compounds (15%). This reproducibility gives a good estimation of the measurement uncertainty.

The global uncertainty was also calculate for both methods. Global uncertainty is the square root of the quadratic sum of uncertainties, and it was calculate following the recommendations from French national organization for standardization (AFNOR, 2008). For that, the volume precision, measure precision and measurement accuracy were computed.

$$u^2 = \Delta x^2 volume + \Delta x^2 measure \quad (1)$$

, were

$$\Delta x^2\ measure = \Delta x^2\ precision + \Delta x^2\ accuracy \quad (2)$$

The uncertainty values (U, in percentage %) for both methods are shown in Table S1 and table S2.

Limit of detection (DL) and limit of quantification (QL) were also estimated and they are shown in Table S1 and S2.

Table S1. Detection limits, quantification limits and global uncertainties for the VOCs analysed at LaMP under GC-MS technique

	DL (pptv)	**QL (pptv)**	**U (%)**
Benzene	10.32	51.59	13.54
Toluene	1.76	8.81	2.53
o-xylene	2.92	14.61	4.23
m+p-xylene	1.29	6.43	3.10
Ethylbenzene	3.96	19.78	3.61
Octane	4.01	20.05	5.58
iso-octane	14.58	72.90	19.58
Heptane	2.34	11.70	9.67
2- methyl pentane	22.57	112.84	10.98
Isoprene	12.19	60.96	19.63
Limonene	1.17	5.84	9.68
β-Pinene	3.00	15.01	6.54
α-Pinene	8.67	43.35	18.52
1,2,3-trimethylbenzene	1.10	5.49	14.33
1,2,4-trimethylbenzene	2.25	11.25	6.92
1,3,5-trimethylbenzene	2.01	10.03	37.94

Table S2. Detection limits and global uncertainties for the VOCs analysed at IMT Lille with GC-FID technique

	DL (pptv)	U (%)		DL (pptv)	U (%)
hexanal	3	21	**octane**	1	n.d.
heptanal	4	21.2	**nonane**	1	9.4
octanal	2	21.4	**decane**	1	5.3
nonanal	4	28.5	**undecane**	1	4.8
decanal	2	29.3	**dodecane**	1	4.9
undecanal	2	21.4	**tridecane**	1	32.6
benzaldehyde	2	n.d.	**tetradecane**	<1	11.5
benzene	1	5.0	**pentadecane**	4	10.9
toluene	2	5.4	**hexadecane**	13	17.3
ethylbenzene	1	4.0	**α-pinene**	<1	4.4
m+p-xylene	<1	5.7	**camphene**	1	5.1
o-xylene	1	3.7	**β-pinene**	3	8.4
styrene	1	n.d.	**α-terpinene**	<1	n.d.
1,3,5-trimethylbenzene	1	n.d.	**limonene**	1	15.2
1,2,4-trimethylbenzene	1	n.d.	**γ-terpinene**	3	n.d.
1,2,3-trimethylbenzene	<1	n.d.	**3-carene**	1	n.d.
pentane	2	n.d.	**α-ocimene**	1	n.d.
2-methyl pentane	1	n.d.	**terpinolene**	1	n.d.
hexane	1	n.d.	**myrcene**	2	n.d.
iso-octane	1	n.d.	**nopinone**	<1	n.d.
heptane	1	n.d.			

Table S3: Particle EFs of each vehicle tested and number of filters, VOC tubes sampled

Sources	**Number of sampling**		**EF (g/kg fuel)**		
	VOCs	**Filters**	**EC**	**OC**	**TPM**
DL_old taxi	2	6	1.880	0.340	10.459
DL_old taxi			2.826	4.143	64.507
DL_old CAR			7.746	5.828	87.287
DL_old CAR			10.619	2.715	100.750
DL_old gbaka*			3.062	2.889	33.143
DL_old gbaka			2.313	1.943	25.580
Mean old LDDV			**4.741**	**2.976**	**53.621**
STD			**3.270**	**1.712**	**33.019**

DL_old Truck	4	4	4.934	3.034	57.181
DL_old Truck			5.131	7.593	84.448
DL_old Bus			0.843	1.819	17.944
DL_old Bus			2.817	2.398	28.978
Mean old HDDV			**3.431**	**3.711**	**47.138**
STD			**1.748**	**2.282**	**25.860**
DL recent gbaka	1	3	2.120	0.844	14.712
DL recent gbaka			1.133	0.717	7.573
DL recent gbaka			0.519	0.250	5.098
Mean recent LDDV			**1.258**	**0.604**	**9.128**
STD			**0.659**	**0.255**	**4.076**
DL_recent Truck	2	2	0.339	0.570	6.103
DL_recent Truck			0.358	0.871	7.262
Mean recent HDDV			**0.348**	**0.721**	**6.682**
STD			**0.010**	**0.150**	**0.580**
Gasoline old car	2	5	0.518	0.770	3.992
Gasoline old car			2.383	4.241	16.264
Gasoline old car			1.626	1.466	8.639
Gasoline old car			0.363	1.660	6.312
Gasoline old car			0.277	0.888	12.965
Mean old LDGV			**1.033**	**1.805**	**9.635**
STD			**0.832**	**1.263**	**4.448**
Gasoline new car	1	3	0.001	0.099	3.302
Gasoline new car			0.001	0.019	3.188
Gasoline new car			0.002	0.007	2.583
Mean recent LDGV			**0.001**	**0.042**	**3.024**
STD			**0.001**	**0.040**	**0.316**
TW 4-strokes	4	4	0.069	0.226	0.724
TW 4-strokes			0.275	0.516	3.657
TW 4-strokes			0.039	0.509	13.108
TW 4-strokes			0.040	0.555	3.998
Mean recent TW 4T			**0.106**	**0.452**	**5.372**
STD			**0.099**	**0.131**	**4.644**
TW 4T vieux	1	1	3.665	25.467	499.872
TW 2-strokes	2	2	0.845	24.587	45.283
TW 2-strokes			3.681	26.837	431.303
Mean recent TW 2T			**2.263**	**25.712**	**238.293**
STD			**1.418**	**1.125**	**193.010**
TW 2T vieux	1	1	3.454	124.214	883.098

*gbaka is a van used for public transport in Côte d'Ivoire

Table S4: GEIA VOC species groups (Huang et al., 2017)

Class	VOCs families	VOC species integrated in this study
VOC1	Alkanols (alcohols)	n.d.
VOC2	Ethane	n.d.
VOC3	Propane	n.d.
VOC4	Butanes	n.d.
VOC5	Pentanes	pentane
VOC6	Hexanes and higher alkanes	2-methylpentane, 3-methylpentane, hexane, 2,2-dimethylpentane, 2,4-dimethylpentane, 2,2,3-trimethylbutane, 3,3-dimethylpentane, cyclohexane, 2-methylhexane, 2,3-dimethylpentane, iso-octane, heptane, octane, nonane, decane, undecane, dodecane, tridecane, tetradecane, pentadecane, hexadecane
VOC7	Ethene (ethylene)	n.d.
VOC8	Propene	n.d.
VOC9	Ethyne (acetylene)	n.d.
VOC10	Isoprenes	isoprene
VOC11	Monoterpenes	α-pinene, β-pinene, camphene, 3-carene, α-terpinene, limonene, α-ocimene, γ-terpinene, terpinolene, myrcene, camphre, borneol
VOC12	Other alk(adi)enes/alkynes (olefines)	n.d.
VOC13	Benzene (benzol)	benzene
VOC14	Methylbenzene (toluene)	toluene
VOC15	Dimethylbenzenes (xylenes)	M+p-xylene, o-xylene, ethylbenzene,
VOC16	Trimethylbenzenes	1,2,4-trimethylbenzene, 1,2,3-trimethylbenzene and 1,3,5-trimethylbenzene
VOC17	Other aromatics	Cumene, styrene
VOC18	Esters	n.d.
VOC19	Ethers (alkoxy alkanes)	n.d.
VOC20	Chlorinated hydrocarbons	n.d.
VOC21	Methanal (formaldehyde)	n.d.
VOC22	Other alkanals (aldehydes)	Benzaldehyde, heptanal, hexanal, octanal, nonanal, decanal, undecanal
VOC23	Alkanones (ketones)	Methylvinylketone, methylethylketone
VOC24	Acids (alkanoic)	n.d.
VOC25	Other NMVOC (HCFCs, nitriles, etc.)	n.d.

Table S5: EFs of emission sources grouped by VOC speciation of GEIA

EF (g/kg fuel)	HDDV	LDDV	LDGV	TW 2T	TW 4T	FW	CHM	WB	CH
VOC6	1.07±0.23	0.60±0.13	2.84±0.20	1148±337	22.5±3.43	2.79±0.93	5.34±1.49	16.0±7.09	1.84±0.49
VOC10	0.02±0.02	0.06+0.06	0.41+0.35	28.3±28.6	1.98±0.85	1.70±1.69	0.70±0.25	2.67±4.33	0.20±0.21
VOC11	0.17±0.04	0.03+0.00	0.06+0.02	53.2±20.5	0.36±0.07	1.94±0.64	0.37±0.11	69.5±26.3	2.03±1.11
VOC12	0.00±0.00	0.21+0.02	2.09+1.02	87.9±106	0.10±0.05	0.00±0.00	0.12±0.12	1.58±2.14	0.27±0.42
VOC13	0.68±0.27	5.57+2.80	4.78+0.37	380±279	32.0±8.56	2.00±1.99	4.20±0.12	19.1±19.0	8.64±11.9
VOC14	0.58±0.18	3.10+1.80	34.8+18.6	1135±830	95.1±32.2	1.53±1.52	4.64±2.02	35.5±45.6	3.60±4.30
VOC15	1.01±0.20	1.62+0.25	93.5+2.25	2127±673	81.3±15.2	1.59±0.79	3.37±0.98	5.86±4.52	2.69±1.26
VOC16	2.13±0.52	2.96+0.21	51.2+0.59	1916±437	46.3±7.00	0.78±0.26	2.89±0.34	4.35±1.92	7.87±4.30
VOC17	0.25±0.11	0.82+0.37	15.6+3.15	815±591	40.6±16.2	0.24±0.24	0.81±0.25	27.9±34.3	1.74±2.07

Table S6: EFs of emission sources grouped by VOC speciation of GEIA for 50 compounds

EF (g/kg fuel)	HDDV	TW 2T	FW	CHM	CH
VOC5	0.07	331.2	0.15	1.03	0.25
VOC6	115.3	6659	10.4	23.8	10.8
VOC10	0.34	46.10	3.39	0.87	0.09
VOC11	19.4	574.7	4.83	3.81	1.06
VOC12	0.92	187.6	0.00	0.45	0.12
VOC13	20.8	617.7	3.99	8.26	3.56
VOC14	9.79	1841	3.05	12.7	1.56
VOC15	12.0	3220	3.17	10.2	1.18
VOC16	22.5	2847	1.55	5.68	3.61
VOC17	4.42	1953	1.30	3.72	1.15
VOC22	33.4	665.7	2.26	17.3	3.53
VOC23	1.14	10.69	0.44	15.2	0.36
IVOCs	80.32	95.07	1.17	6.32	0.73

Table S7: VOC-EFs from diesel and gasoline light- and heavy-duty vehicles and wood burning in this study and literature

EF	HDDV	std	LDDV	std	LDGV	std	FW	std	Gasoline_HDL[	std	std	std	WB maximum	std	WB maximum	std
Unit	(g/kgdm)		(g/kgdm)		(g/kgdm)		(g/kgdm)		g/L		g/L		g/L		g/kg	
Reference	This study								Gentner et al., 2016				Evtyugina et al, 2015		McDonaldet al., 2000	
heptane	0.23	0.16	0.18	0.13	0.44	0.15	0.04	0.04	0.042				0.019	0.002	0.005	0.003
octane	0.74	0.46	0.21	0.1	2.36	0.4	2.38	2.3	0.020	0.001	0.004	0.003	0.005	0.001	0.004	0.003
iso-octane	0.09	0.07	0.21	0.15	0.04	0.03	0.37	0.6	0.067	0.032	0.000	0.000				
benzene	0.68	0.27	5.6	2.8	4.78	0.4	2	1.98	0.227	0.012	0.006	0.005	0.901	0.131	0.312	0.083
toluene	0.58	0.17	3.1	1.8	34.7	18.6	1.53	1.52	0.226	0.014	0.022	0.013	0.326	0.047	0.142	0.004
m+p-xylene	0.7	0.26	1.06	0.27	63.4	1.07	1.43	1.42	0.079	0.004	0.007	0.004	0.040	0.007	0.041	0.012
o-xylene	0.32	0.15	0.56	0.22	30.1	3.43	0.16	0.47	0.057	0.004	0.004	0.003	0.027	0.002		
ethylbenzene	0.25	0.11	0.82	0.37	15.6	3.15	0.24	2.07	0.033	0.004	0.009	0.005	0.053	0.006		
135-TMB	0.33	0.21	0.52	0.14	10.8	0.56	0.07	0.02	0.019	0.000	0.015	0.008	0.001	0.000		
124-TMB	1.29	0.96	1.73	0.34	34.6	0.84	0.06	0.08	0.093	0.001	0.046	0.024				
123-TMB	0.5	0.4	0.71	0.14	5.84	0.36	0.65	12.7								
isoprene	0.02	0.02	0.06	0.06	0.41	0.35	1.69	0.2					0.111	0.016	0.027	0.013
limonene	0.07	0.06	0.02	0.01	0	0	1.91	1.87					0.001	0.001	0.018	0.027
a-pinene	0.04	0.02	0	0	0.01	0.01	0	1.5					0.009	0.004	0.004	0.004
b-pinene	0.06	0.05	0.01	0	0.05	0.03	0.03	1.72								

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