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A pilot study of gaseous pollutants' measurement (NO_2, SO_2, NH_3, HNO_3 and O_3) in Abidjan, Côte d'Ivoire: contribution to an overview of gaseous pollution in African cities

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Supplementary material

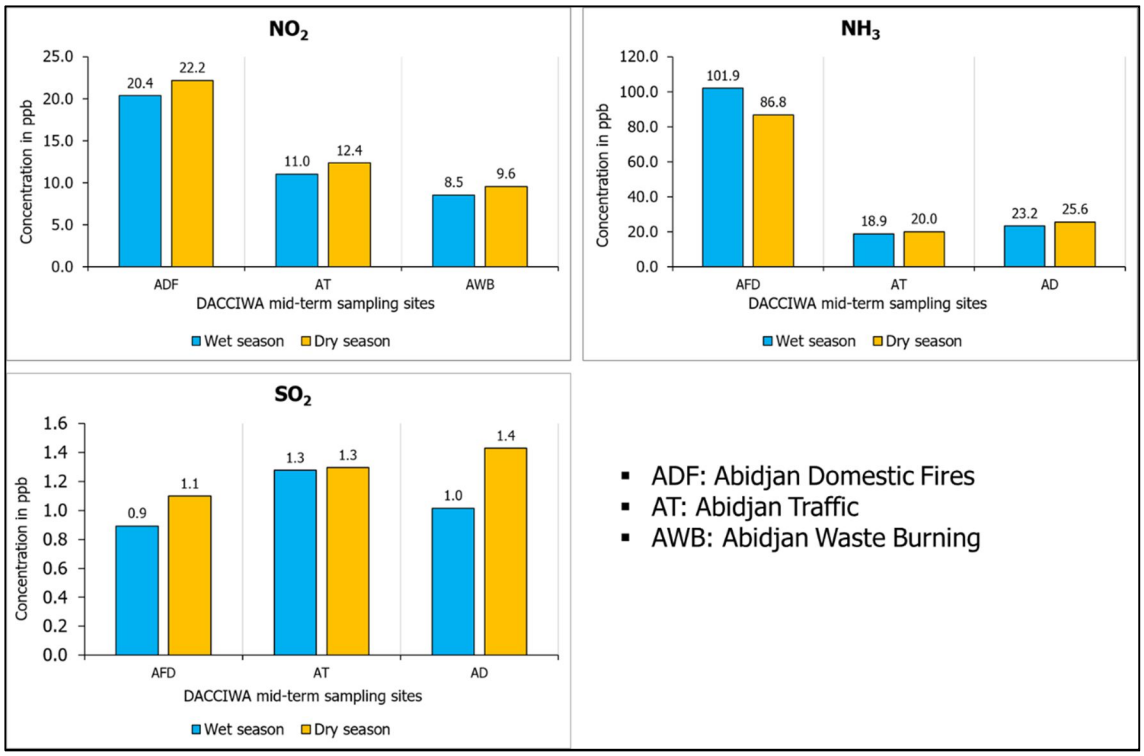

Figure S 1: Seasonal variation of primary gaseous pollutants in Abidjan from December 2014 to April 2017.

Table S 1: Ratio between nitrite (NO2-) and nitrate (NO_3-) ions detected in IC for NO_2 filters. Results for Abidjan Traffic site (A_1)

NO2 sampler	Concentration (µg/L)			Concentration (ppbv)		
	NO2_$NO2^-$	**NO2_$NO3^-$**	**Ratio (%)**	**NO2_$NO2^-$**	**NO2_$NO3^-$**	**Ratio (%)**
SA1 1016 f	752	18	2.39	10.23	0.19	1.88
SA1 1016 f	747	10	1.34	10.16	0.08	0.81
SA1 1116 d	937	22	2.35	11.16	0.22	1.94
SA1 1116 d	964	21	2.18	11.48	0.20	1.78
SA1 1116 f	932	13	1.39	11.95	0.12	0.97
SA1 1116 f	906	44	4.86	11.62	0.52	4.45
SA1 1216 d	1058	36	3.40	13.45	0.44	3.24
SA1 1216 d	1214	46	3.79	15.45	0.56	3.65
SA1 1216 f	1327	18	1.36	16.99	0.21	1.21
SA1 1216 f	1401	27	1.93	17.94	0.32	1.79
SA1 0117 d	1199	23	1.92	14.24	0.25	1.76
SA1 0117 d	1179	23	1.95	14.00	0.25	1.79
SA1 0117 f	999	17	1.70	12.15	0.18	1.51
SA1 0117 f	1002	20	2.00	12.19	0.22	1.81
SA1 0217 d	1236	22	1.78	15.50	0.13	0.82
SA1 0217 d	1274	23	1.81	15.99	0.14	0.88
SA1 0217 f	774	29	3.75	11.28	0.26	2.26
SA1 0217 f	623	27	4.33	9.02	0.23	2.50
SA1 0317 d	723	25	3.46	9.05	0.17	1.85
SA1 0317 f	820	29	3.54	8.13	0.17	2.13
SA1 0417 d	755	22	2.91	10.91	0.15	1.36
SA1 0417 d	672	23	3.42	9.68	0.16	1.69
Mean	**727.8**	**25.8**	**3.6**	**9.7**	**0.2**	**2.0**

Table S 2: Average inorganic gaseous pollutants concentrations measured each two-week periods

Sampling site	15 December 2015 - 1 January 2016					1 January 2016 - 15 January 2016					15 January 2016 - 1 February 2016					1 February 2016 -15 February 2016				
	NO_2	NH_3	SO_2	HNO_3	O_3	NO_2	NH_3	SO_2	HNO_3	O_3	NO_2	NH_3	SO_2	HNO_3	O_3	NO_2	NH_3	SO_2	HNO_3	O_3
A1	30.8	43.3	5.4	0.9	10.1	18.9	26.7	2.1	1.3	12.0	19.7	31.0	2.1	1.1	10.6	13.9	23.3	0.9	1.2	12.6
A2	13.1	31.6	7.8	0.7	10.4	12.1	28.2	4.9	0.6	13.0	10.8	25.4	6.1	0.6	13.3	10.4	25.1	8.2	0.7	13.0
A3	15.7	28.2	8.1	0.5	7.2	11.3	23.7	5.4	0.3	9.1	10.9	21.9	6.6	0.4	9.0	10.9	20.2	8.8	0.5	10.3
A4	8.7	38.5	3.8	0.2	4.0	7.9	33.4	5.1	0.2	5.5	7.0	30.7	6.0	0.3	5.4	7.1	26.2	4.0	0.3	5.6
A5	33.6	22.6	4.4	0.6	6.9	21.2	19.0	2.0	1.0	8.2	21.1	26.7	2.1	1.1	8.0	19.7	23.8	4.0	1.9	7.9
A6	8.0	22.5	0.7	0.6	14.0	5.3	17.4	0.3	1.0	21.1	6.5	19.0	0.5	1.0	22.4	7.6	16.4	0.2	0.9	17.6
A7	23.4	58.8	2.5	0.7	8.7	16.0	28.2	1.6	1.5	12.8	16.7	32.2	1.0	0.6	12.0	13.9	28.8	0.9	1.8	15.9
A8	24.6	37.0	2.6	0.7	7.4	20.3	24.7	1.3	1.2	11.3	18.6	31.4	1.0	0.8	9.8	18.0	29.4	0.7	1.6	13.3
A9	26.7	26.5	2.5	0.9	10.9	17.7	16.7	1.7	1.4	14.8	19.6	20.9	2.4	1.2	11.0	15.7	22.3	0.5	1.7	12.1
A10	19.7	24.5	2.3	0.8	9.0	16.2	20.5	1.7	0.9	11.6	17.6	22.9	1.5	0.7	7.0	17.2	15.5	0.9	0.6	7.7
A11	25.9	19.1	2.9	0.5	11.0	23.9	21.8	1.2	0.8	9.6	22.7	16.9	1.5	0.6	11.9	27.6	20.7	1.9	1.0	5.8
A12	17.3	18.4	0.8	0.6	13.4	12.2	19.4	0.5	1.0	13.7	12.0	24.3	0.7	0.8	14.0	8.4	33.5	0.6	1.5	15.1
A13	22.8	28.9	1.9	0.8	9.1	16.9	24.6	1.5	1.3	16.1	15.8	29.6	1.7	1.1	13.0	18.3	24.4	1.8	1.8	13.5
A14	21.5	57.6	1.6	0.5	5.3	16.8	61.3	1.1	0.8	12.4	15.8	80.5	0.6	0.4	6.9	16.3	71.5	1.1	0.7	5.9
A15	13.3	37.5	0.4	0.9	16.1	11.3	36.9	0.6	1.3	15.2	9.9	43.3	1.1	1.2	19.2	13.6	38.6	2.5	1.8	19.6
A16	18.8	83.9	1.0	1.1	9.9	17.8	107.5	1.3	1.0	12.8	17.6	107.6	1.4	1.6	7.7	18.9	109.4	0.8	1.0	10.3
A17	21.0	16.8	1.7	1.2	11.2	11.6	16.0	0.8	1.3	19.1	12.5	25.6	0.7	1.0	16.4	9.4	31.5	1.0	2.0	20.4
A18	2.9	12.4	1.9	0.4	10.1	2.5	8.8	1.4	0.7	12.6	2.6	7.7	2.1	0.9	12.8	2.6	7.5	2.0	0.6	13.7
A19	5.7	47.2	2.3	0.2	5.4	4.9	45.1	2.4	0.2	7.1	5.2	42.0	3.8	0.2	7.0	5.6	41.7	4.9	0.2	7.8
A20	7.0	18.8	0.3	0.7	15.9	6.8	11.0	0.4	0.1	21.4	6.0	15.0	0.5	0.9	18.9	7.7	12.3	0.4	1.5	20.2
A21	7.4	15.6	0.3	0.4	10.9	5.3	11.3	0.4	0.8	14.5	6.0	17.5	0.6	0.8	15.3	5.1	9.9	0.3	0.5	13.9

Table S 3: NO_2 concentration levels in µg.m^{-3} in African capitals at different time scale (hourly, daily, weekly, monthly, and annually) as reported in literature

Country	City	exposure time	NO_2 concentration			References
			min	max	mean	
Senegal	Dakar	Annual	3.5	19.6	-	Demay et al., 2011
Burkina Faso	Ouagadougou		22	27	-	Nanaa et al., 2012
South Africa	Northeastern		2	7	-	Josipovic et al., 2010)
Tunisia	Ben Arous		-	-	178	Chaaban, 2008
Senegal	Dakar		41.37	84.61	59.6	Adon et al., 2016
Mali	Bamako		18.8	41.37	30.46	Adon et al., 2016
Côte d'Ivoire	Abidjan traffic		21.34	25.95	23.25	Bahino PhD, 2017
Mozambique	Maputo	Monthly	2.6	21.0	9.1	Cumbane et al., 2008
Senegal	Dakar		48.0	70.0	-	Liousse et Galy-Lacaux, 2010
Côte d'Ivoire	Abidjan		28.2	31.2	29.8	Liousse et Galy-Lacaux, 2010
Cameroon	Yaoundé		15.0	51.7	33.3	Liousse et Galy-Lacaux, 2010
Burkina Faso	Ouagadougou		51.1	66.9	57.7	Liousse et Galy-Lacaux, 2010
Mali	Bamako		32.7	87.2	58.0	Liousse et Galy-Lacaux, 2010
Côte d'Ivoire	Abidjan Traffic		22.6	44.9	33.5	This study
Côte d'Ivoire	Abidjan Industrial		14.4	47.0	39.3	This study
Nigeria	Imo State	Weekly	864	1015.34	-	Ibe et al., 2016
Ouganda	Kampala	2 weeks	9.32	52.9	24.9	Kirenga et al., 2015
Ghana	Accra	96 Hours	21.06	66.75		Arku et al., 2008
Benin	Cotonou	Daily	169.22	752.1	-	Mama et al, 2013
Kenya	Nairobi		0.1	245	-	Kaboro Beth, 2006
Morocco	Marrackech		10	35	-	Inchaouh et al., 2017
Egypt	Cairo		-	-	164	Chaaban, 2008
Nigeria	Niger Delta		224	472	-	Obanijesu, 2009
Egypt	Cairo		33.4	93.7	66.8	Hassan et al., 2013
Ethiopia	Addis Ababa		-	-	-	Abera Kumie, 2009
Mali	Bamako		24.82	93.26	59.6	Adon et al., 2016
Tanzania	Dar El Salam	Hourly	18	53	-	Jackson, 2005
Senegal	Dakar		9.4	150	-	Adon et al., 2016
Mali	Bamako		15.8	135	-	Adon et al., 2016

Table S 4: SO_2 concentration levels in µg.m^{-3} in African capitals at different time scale (hourly, daily, weekly, monthly, and annually) as reported in literature.

Country	City	exposure time	SO_2 concentration			References
			min	max	mean	
Algeria	Alger	Annual	-	-	360	Chaaban, 2008
Tunisia	Ben Arous		-	-	104	Chaaban, 2008
Nigeria	Lagos		6.01	50.22	-	Raheem et al 2009
Egypt	Cairo		-	-	69	Chaaban, 2008
Morroco	Rabat		8	144	-	Chaaban, 2008
Burkina Faso	Ouagadougou		0.5	10.5	-	Nanaa et al., 2012
South africa	Notheastern		2	29	-	Josipovic et al, 2010
Kenya	Nairobi		4.9	119.4	-	Kaboro, 2006
Senegal	Dakar		10.46	83.7	41.6	Adon et al., 2016
Mali	Bamako		5.23	18.31	9.42	Adon et al., 2016
Côte d'Ivoire	Abidjan		2.77	3.66	3.5	Bahino PhD, 2017
Mozambique	Maputo	Monthly	0.48	16.05	1.25	Cumbane et al., 2008
Côte d'Ivoire	Abidjan Traffic		3.63	18.86	11.09	This study
Côte d'Ivoire	Abidjan Industrial		4.19	4.92	4.58	This study
Nigeria	Imo state	weekly	1203	1465	-	Ibe et al 2016
Ouganda	Kampala	2weeks	0.77	8.35	3.79	Kirenga et al., 2015
Ghana	Accra	96 Hours	2.87	3.21	-	Arku et al., 2008
Kenya	Nairobi	Daily	0.2	476.5	119.4	Kaboro, 2006
Morocco	Marrakech		8	12	-	Inchaouh et al., 2017
Sudan	Karthoum		4	180	-	khogali, 2016
Tunisia	Tunis		0.36	15.17	-	Kchih and cherif, 2015
Benin	Cotonou		784.8	3662.4	-	Mama et al., 2013
Egypt	Cairo		17.2	57.2	34	Hassan et al., 2013
Senegal	Dakar		30.34	102.55	68.54	Adon et al., 2016
Mali	Bamako		12.81	51.27	29.03	Adon et al., 2016
Tanzania	Dar-es-salam	Hourly	558	1385	-	Jackson, 2005
Senegal	Dakar		14.38	136.03	-	Adon et al., 2016
Mali	Bamako		9.41	60.7	-	Adon et al., 2016