Emission Factors for Biochar Production from Various Biomass Types in Flame Curtain Kilns

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Table S1: Raw data for pyrolysis of maize cobs.

Maize cobs	Weight	wet	dry	C content
	Feedstock (kg)	21.4	19.0	0.486
	Biochar (kg)	19.8	4.77	0.816
	BC yield (%)		25.15	

Phase	**Time**	**CO2**	**CO**	**CH4**	**NO2**	**PM10**
		%	**ppm**	**%**	**ppm**	**mg/m³**
Startup twigs	12:20	0.58	99	0	0	12
First maize cobs	12:22	0.75	215	0	0	28
Maize cobs, stable run	12:50	0.6	55	0	1	5.7
Maize cobs, stable run	13:02	0.57	60	0	0.7	4.8
Maize cobs, stable run	13:08	0.6	76	0	0	7.7
Maize cobs, stable run	13:10	0.63	90	0	0	6.9
Maize cobs, stable run	13:15	0.59	83	0	0	1.8
Maize cobs, stable run	13:18	0.6	160	0	0.2	24
Maize cobs, stable run	13:21	0.66	105	0	0.3	4.2
Maize cobs, stable run	13:25	0.57	149	0	0.1	20.5
Maize cobs, stable run	13:29	0.69	139	0	0.2	14.5
Maize cobs, stable run	13:31	0.65	242	0	0.4	55
Maize cobs, stable run	13:34	0.52	150	0	0	7.7
Maize cobs, stable run	13:37	0.48	130	0	0.4	12
Maize cobs, stable run	13:40	0.61	105	0	0.4	12
Maize cobs, stable run	13:43	0.65	113	0	0	14.1
Maize cobs, stable run	13:46	0.75	107	0	0.4	5.3
Maize cobs, stable run	13:49	0.77	81	0	0	10.3
Maize cobs, stable run	13:52	0.66	123	0	0.8	5
Maize cobs, stable run	13:55	0.77	221	0	0.5	13.6
Quenching	13:56	0.5	298	0	0	5.2

Table S2: Raw data for pyrolysis of sesame stems.

Sesame stems	Weight	wet	dry	C content
	Feedstock (kg)	39.2	35.28	0.445
	Biochar (kg)	52.0	9.10	0.545
	BC yield (%)		25.79	

Phase	**Time**	**CO2**	**CO**	**CH4**	**NO2**	**PM10**
		%	**ppm**	**%**	**ppm**	**mg/m³**
Startup sesame stems	16:00	1.5	224	0	0	47.8
Sesame stems, stable run	16:01	1.6	219	0	0.6	85
Sesame stems, stable run	16:03	1.5	176	0	0.8	514
Sesame stems, stable run	16:06	1.7	291	0	0.4	75.1
Sesame stems, stable run	16:07	1.4	288	0	0	67.9
Sesame stems, stable run	16:09	1.4	302	0	0.4	85
Sesame stems, stable run	16:11	1.2	415	0	0.2	72.4
Sesame stems, stable run	16:13	1.9	442	0	0	142
Sesame stems, stable run	16:15	1.6	390	0	0.6	105
Sesame stems, stable run	16:20	1.6	340	0.125	0	211
Sesame stems, stable run	16:22	2.1	1121	0	1.4	126
Sesame stems, stable run	16:24	2.6	616	0	1.5	289
Sesame stems, stable run	16:26	2.6	652	0	1.1	181
Sesame stems, stable run	16:28	2.9	1444	0	1.6	300
Sesame stems, stable run	16:30	1.8	1002	0	1	104
Sesame stems, stable run	16:31	1.8	484	0	1.1	91
Quenching	16:33	0.6	700	0.57	0	1.8

Table S3: Raw data for pyrolysis of grass.

Grass	Weight	wet	dry	C content
	Feedstock (kg)	66.8	60.1	0.416
	Biochar (kg)	55.9	13.0	0.488
	BC yield (%)		21.66	

Phase	**Time**	**CO2**	**CO**	**CH4**	**NO2**	**PM10**
		%	**Ppm**	**%**	**ppm**	**mg/m^3**
Startup twigs	15:10	0.9	100	0	0	20.4
First grass	15:11	0.69	130	0	0	21.9
Grass, stable run	15:12	1.1	97	0	0.4	14.4
Grass, stable run	15:15	1.4	102	0	0	25.2
Grass, stable run	15:16	1.3	99	0	1.9	65
Grass, stable run	15:18	1.4	85	0	0	23.1
Grass, stable run	15:21	2	132	0	1.1	30.3
Grass, stable run	15:25	1.9	145	0	0.8	17.2
Grass, stable run	15:27	1.7	146	0	0.5	40.8
Grass, stable run	15:31	2.4	135	0	0.5	21.5
Grass, stable run	15:33	2.1	158	0	0.6	23.1
Grass, stable run	15:35	1.9	172	0	0	28.5
Grass, stable run	15:39	1.7	160	0	0.6	22.4
Grass, stable run	15:41	3	154	0	0	87.3
Grass, stable run	15:44	3.8	201	0	1.5	59
Quenching	15:45	1.3	450	0	0	2.2

Table S4: Raw data for pyrolysis of grass/twigs.

Grass/twigs	Weight	wet	dry	C content
	Feedstock (kg)	70.7	63.63	0.445
	Biochar (kg)	53.9	14.41	0.679
	BC yield (%)		22.64	

Phase	**Time**	**CO2**	**CO**	**CH4**	**NO2**	**PM10**
		%	**ppm**	**%**	**ppm**	**mg/m^3**
Startup twigs	10:04	0.4	52	0	0	12
First grass	10:06	1.3	79	0	0	18
Grass + twigs, stable run	10:08	1.1	89	0	0	10
Grass + twigs, stable run	10:10	1.2	150	0	0	10
Grass + twigs, stable run	10:12	1.3	166	0	0	19.4
Grass + twigs, stable run	10:14	1.4	70	0	0	116
Grass + twigs, stable run	10:16	1.3	85	0	0.6	89
Grass + twigs, stable run	10:18	2.1	70	0	0	50
Grass + twigs, stable run	10:20	1.9	98	0	0	40
Grass + twigs, stable run	10:24	1.5	90	0	0	32
Grass + twigs, stable run	10:28	1.3	93	0	0.4	51
Grass + twigs, stable run	10:30	1.7	288	0	0	30
Grass + twigs, stable run	10:32	1.7	99	0	0	83
Grass + twigs, stable run	10:36	2.1	144	0	0.8	58
Grass + twigs, stable run	10:40	1.7	300	0	0	5.2
Grass + twigs, stable run	10:46	2.1	277	0	0	33
Grass + twigs, stable run	10:50	2.5	120	0	0.2	94
Grass + twigs, stable run	10:54	1.5	400	0	0	23
Quenching	10:56	0.85	400	0	0	3.5

Table S5: Raw data for pyrolysis of coffee husk.

Coffee husk

Phase	Time	CO2	CO	CH4	NO2	PM10
		%	ppm	%	ppm	mg/m^3
Coffee husk	18:05	1.56	Not measured	0.05	0	406
Coffee husk	18:07	1.8	Not measured	0.075	0	450
Coffee husk	18:08	1.76	Not measured	0.025	0	555
Coffee husk	18:11	1.5	Not measured	0.15	0	200

Figure S1: The setup of the flame curtain kilns in Gulu, Uganda, with steel plates to shield from the wind and create most possible representative conditions. Gases are sampled from the top of the chimney and led to the devices by internal pumps via the tubes.



Figure S2: The devices deployed to monitor emissions.



Figure S3: Using a rake to slightly lift newly added grass to allow enough oxygen access to combust all the syngases.

