

Supplemental information

June 7, 2020

Contents

Table S1.	Measured PAHs, chemical characteristics, and laboratory analytical parameters, including method detection limit (MDL), quantification and qualification ions, and elution time. MDL must be divided by sampling volume in m ³ to get field MDL.....	7
Table S2.	Chronic non-cancer and cancer information for the PAHs. EPA RfC is reference concentration	8
Table S3.	Occupational and residential characteristics of e-waste workers. Number of responses and percentage in parenthesis, unless otherwise indicated.....	9
Table S4.	Worker classification and time spent in different activities by classification of e-waste workers. Notes: (1) includes all workers; (2) includes only workers classified using stop-motion photography. Bottom portion applies only to 31 workers with filters analyzed for PAHs.	10
Table S5.	Gravimetric and adjusted optical PM concentrations (µg/m ³) at the e-waste site (Agbogbloshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile. 11	11
Table S6.	Unadjusted optical PM concentrations (µg/m ³) at the e-waste site (Agbogbloshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile.	12
Table S7.	Mean and median levels of PM _{2.5} , PM ₁₀ , PAH and PAH abundance by worker activities, all based on coded time lapse photos. Job_Avail_Categories (burner, dismantler, collector, trader, transporter, other) are mutually exclusive categories. Other activities are not mutually exclusive but require a minimum of 30 min.....	13
Table S8.	PAH concentrations (total, low and high molecular weight) concentrations (ng/m ³) at the e-waste site (Agbogbloshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile.	14
Table S9.	Abundances PAH concentrations (total, low and high molecular weight) concentrations (ng/m ³) at the e-waste site (Agbogbloshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile.	15
Table S10.	Summary of PAH concentrations in personal samples (top) and PAH abundances (bottom). AG = Agbogbloshie; MD = Madaina. Statistically significant differences between sites highlighted in yellow for P<0.10 and in pink for P<0.05.....	16
Table S11.	Comparison of PM associated PAHs concentrations from other e-waste and urban studies..	17
Figure S1.	Top: A participant wearing the sampling backpack (side view). Bottom: View of backpack's shoulder strap with Impact sampler (gold color) and OPC inlet.	2
Figure S2.	Experimentally determined particle losses for the inlet and tubing in the backpack Aerocet sampling system. A. Applies to PM ₁ , PM _{2.5} , PM ₄ , PM ₇ , and PM ₁₀ . B. Applies to stated size fractions.....	3
Figure S3.	Calculated particle loss for the inlet and tubing in the backpack Aerocet sampling system.	3
Figure S4.	Scatterplot of optical versus gravimetric PM _{2.5} concentrations. A. Includes pairs of observations with coverage of 80% or more. N=337. B. Includes pairs with coverage of 98%. N=118.....	4
Figure S5.	Scatterplot of optical PM ₁₀ optical PM _{2.5} concentrations. N=281 at Agbogbloshie and N=118 at Madina.. ..	4
Figure S6.	Scatterplot PAH abundance versus PM _{2.5} concentrations for 6 PAHs. N=34.	5
Figure S7.	Abundances of PAH concentrations at Agbogbloshie (N=24) and Madina (N=10) ranked by concentration. Uses median abundance. Symbols * and x denote statistical difference at P=0.05 and P=0.10 levels, respectively, using M-W test.	6

Figure S1. Top: A participant wearing the sampling backpack (side view). Bottom: :View of backpack's shoulder strap with Impact sampler (gold color) and OPC inlet.

impact sampler and OPC inlet on a shoulder strap of the backpack



Figure S2. Experimentally determined particle losses for the inlet and tubing in the backpack Aerocet sampling system. A. Applies to PM1, PM2.5, PM4, PM7, and PM10. B. Applies to stated size fractions.

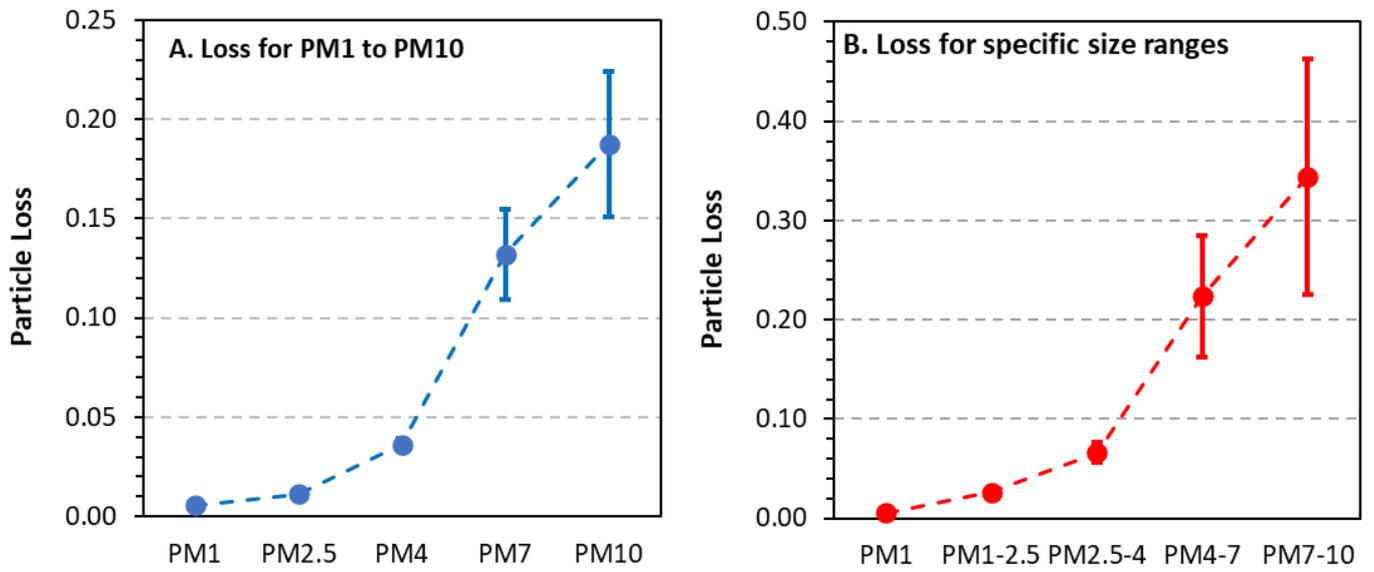


Figure S3. Calculated particle loss for the inlet and tubing in the backpack Aerocet sampling system.

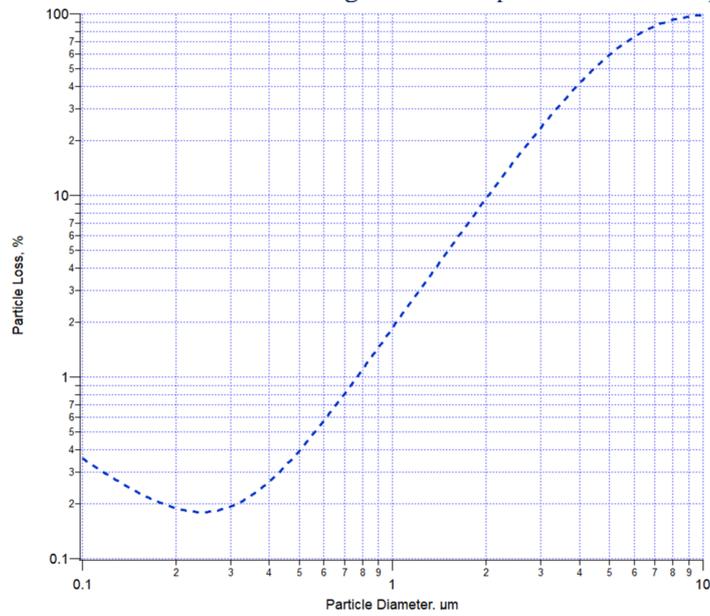


Figure S4. Scatterplot of optical versus gravimetric PM_{2.5} concentrations. A. Includes pairs of observations with coverage of 80% or more. N=337. B. Includes pairs with coverage of 98%. N=118.

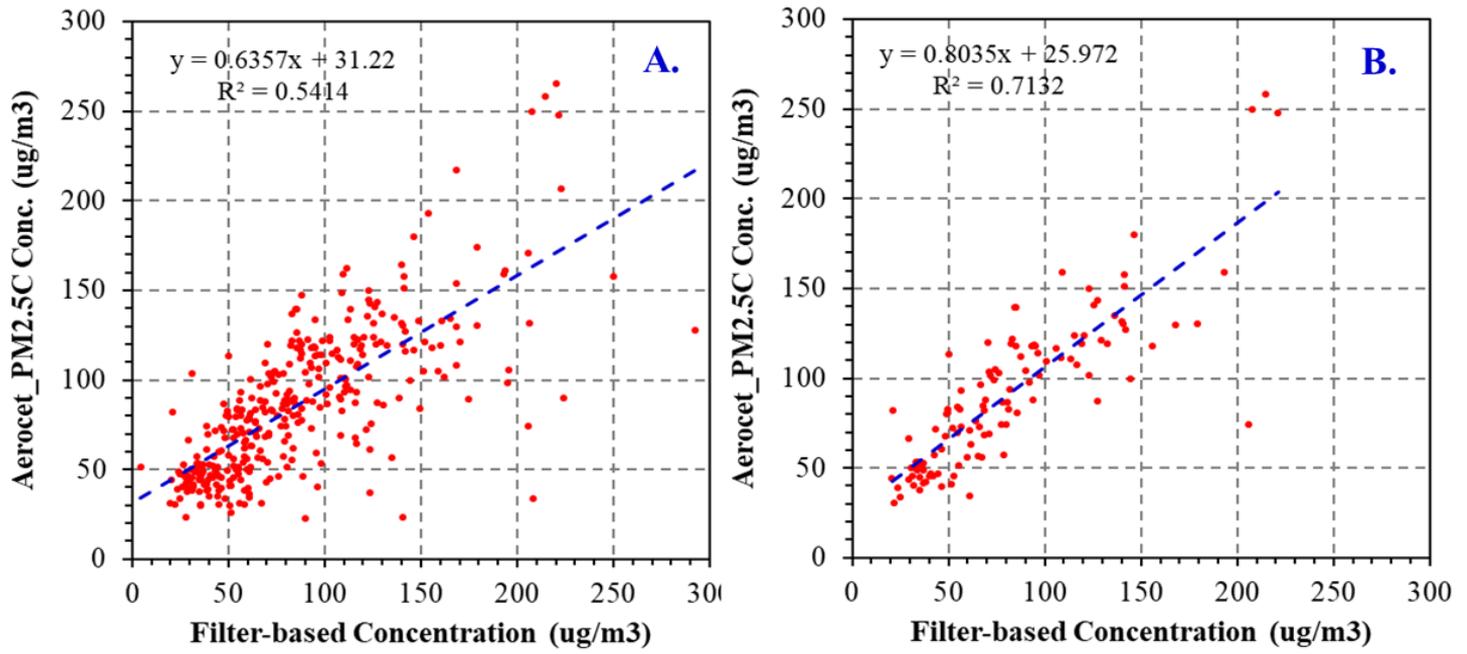


Figure S5. Scatterplot of optical PM₁₀ optical PM_{2.5} concentrations. N=281 at Agboglobshie and N=118 at Madina..

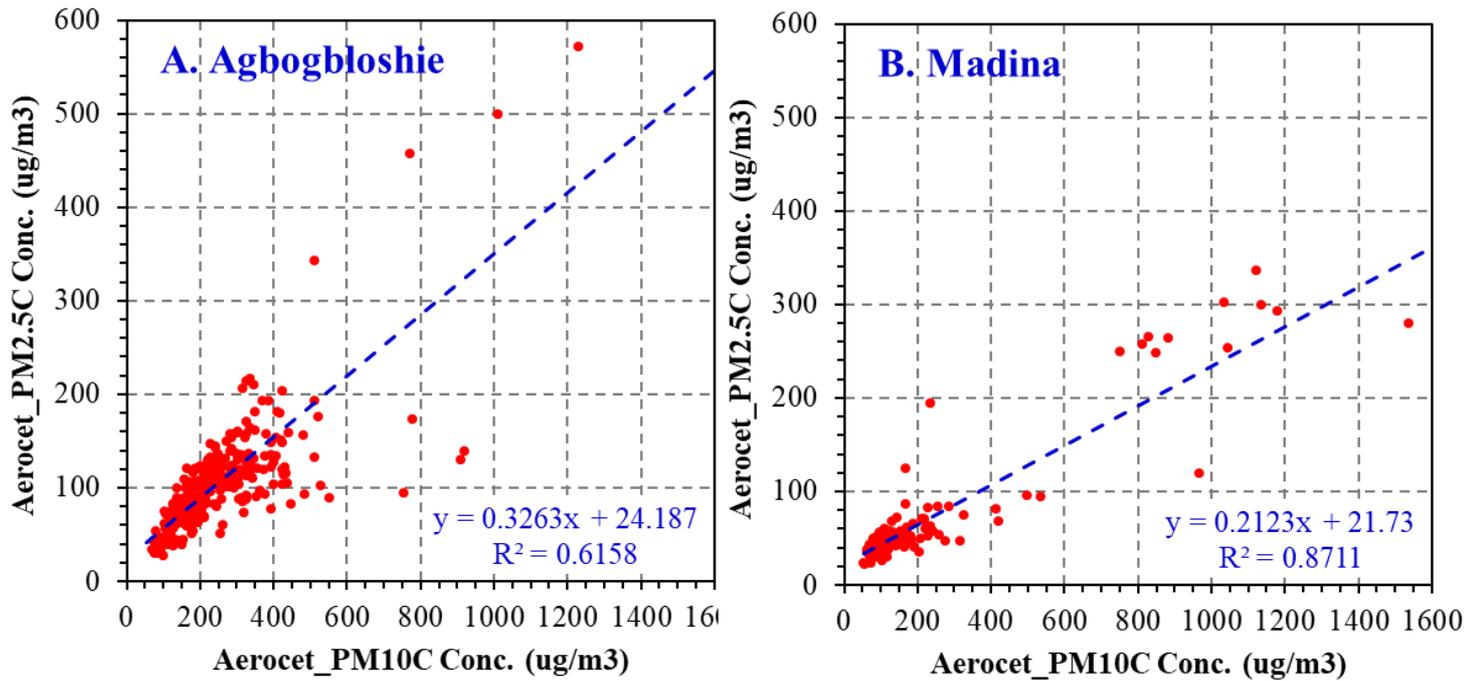


Figure S6. Scatterplot PAH abundance versus PM_{2.5} concentrations for 6 PAHs. N=34.

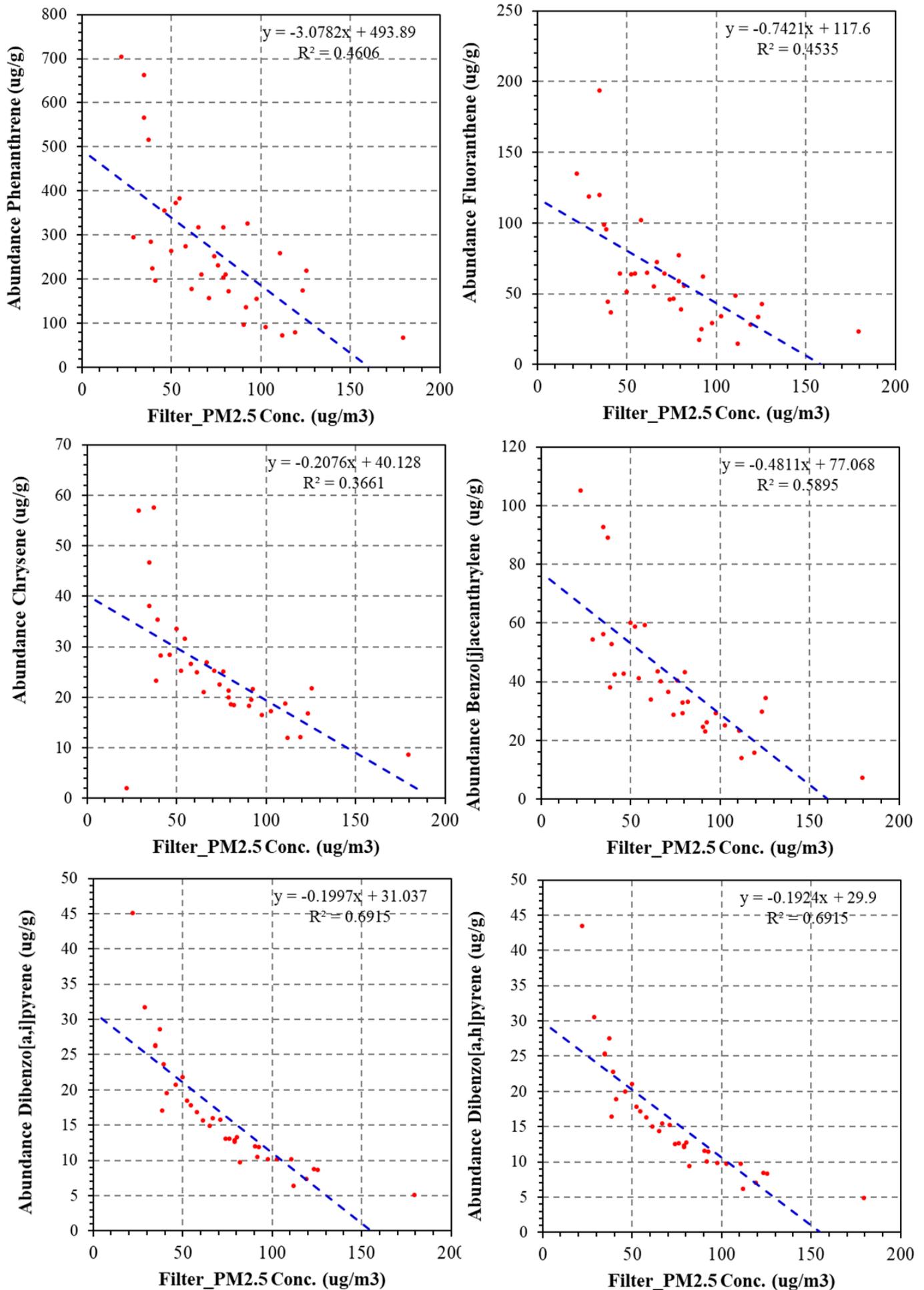


Figure S7. Abundances of PAH concentrations at Agbogbloshie (N=24) and Madina (N=10) ranked by concentration. Uses median abundance. Symbols * and x denote statistical difference at P=0.05 and P=0.10 levels, respectively, using M-W test.

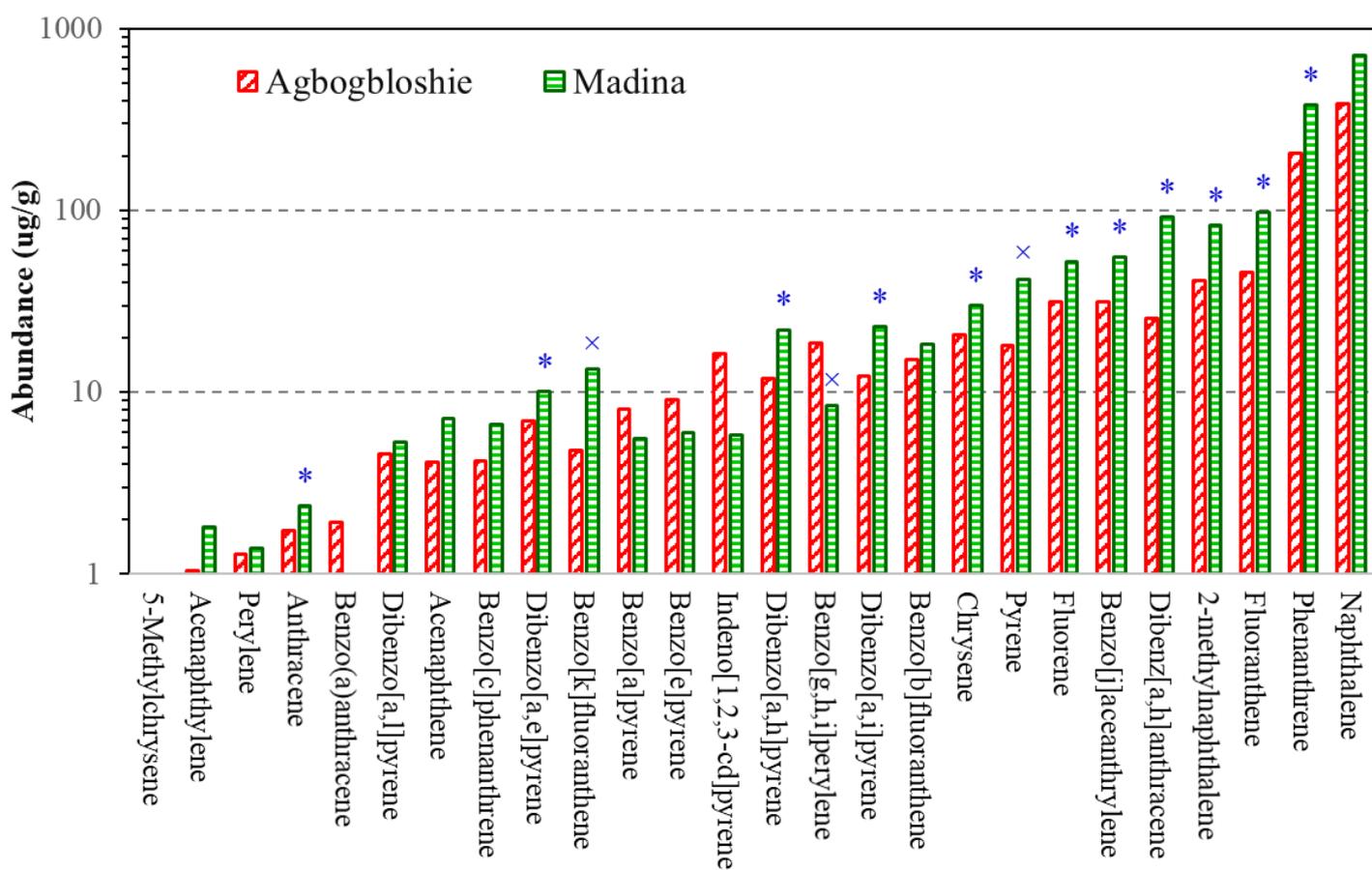


Table S1. Measured PAHs, chemical characteristics, and laboratory analytical parameters, including method detection limit (MDL), quantification and qualification ions, and elution time. MDL must be divided by sampling volume in m³ to get field MDL.

No	Name	Abbreviation	CAS number	Formula	No. Rings	GC-MS Information				
						MDL (ng/mL)	Quan Ion (m/z)	Qual Ion1 (m/z)	Qual Ion2 (m/z)	Elution Time (min)
1	Naphthalene	NAP	91-20-3	C10H8	2	0.190	128	129	127	6.44
2	2-methylnaphthalene	2M-NAP	91-57-6	C11H10	2	0.190	142	141	115	7.44
3	Acenaphthylene	ACY	208-96-8	C12H8	3	0.270	152	151	153	9.69
4	Acenaphthene	ACT	83-32-9	C12H10	3	1.060	153	154	152	10.25
5	Fluorene	FLU	86-73-7	C13H10	3	0.480	166	165	167	11.91
6	Phenanthrene	PHEN	85-01-8	C14H10	3	0.160	178	176	179	15.58
7	Anthracene	ANT	120-12-7	C14H10	3	0.410	178	178	179	15.77
8	Fluoranthene	FLA	206-44-0	C16H10	4	0.210	202	200	203	20.03
9	Pyrene	PYR	129-00-0	C16H10	4	0.280	202	200	203	20.74
10	Chrysene	CHR	218-01-9	C18H12	4	0.240	228	226	229	24.48
11	Benzo[c]phenanthrene	BC-PHEN	195-19-7	C18H12	4	0.230	228	226	227	23.80
12	Benzo(a)anthracene	BAA	56-55-3	C18H12	5	0.160	228	226	227	24.36
12	Cyclopenta[c,d]pyrene	CPPYR	27208-37-3	C18H10	4	0.160	228	226	227	24.36
13	5-Methylchrysene	5M-CHR	3697-24-3	C19H14	4	0.270	242	241	243	25.71
14	Benzo[b]fluoranthene	BBF	205-99-2	C20H12	5	0.280	252	250	253	27.31
15	Benzo[k]fluoranthene	BKF	207-08-9	C20H12	5	0.240	252	250	253	27.38
16	Benzo[j]aceanthrylene	BE-ACY	199-54-2	C20H12	5	1.000	252	250	253	27.71
16	Benzo[e]aceanthrylene	BJ-ACY	202-33-5	C20H12	5	1.000	252	250	253	27.71
17	Benzo[a]pyrene	BAP	50-32-8	C20H12	5	0.270	252	250	253	28.27
18	Benzo[e]pyrene	BEP	192-97-2	C20H12	5	0.190	252	250	253	28.12
19	Perylene	PERL	198-55-0	C20H12	5	0.330	252	250	253	28.53
20	Indeno[1,2,3-cd]pyrene	IND	193-39-5	C22H12	6	0.830	276	277	274	32.46
21	Dibenzo[a,h]anthracene	DBA	53-70-3	C22H12	5	0.140	278	276	279	32.57
22	Benzo[g,h,i]perylene	BGHI-PERL	191-24-2	C22H12	6	0.700	276	277	274	33.69
23	Dibenzo[a,l]pyrene	DAI-PYR	191-30-0	C24H14	6	1.100	302	300	281	40.64
24	Dibenzo[a,e]pyrene	DAE-PYR	192-65-4	C24H14	6	2.400	302	300	281	43.35
25	Dibenzo[a,i]pyrene	DAI-PYR	189-55-9	C24H14	6	5.460	302	300	281	44.42
26	Dibenzo[a,h]pyrene	DAH-PYR	189-64-0	C24H14	6	5.260	302	300	281	45.02

Table S2. Chronic non-cancer and cancer information for the PAHs. EPA RfC is reference concentration

No	Name	Non-Cancer Effects			Cancer Effects				
		EPA RfC (mg/m3)	Effects	Ref	EPA WOE	IARC WOE	Risk Factor (m3/ug)	Effects	Reference
1	Naphthalene	3.0E-03	Metemoglobinemia, chronic nasal inflammation, olfactory epithelial metaplasia, and respiratory epithelial hyperplasia.	OEHHA (2005)	C	2B	3.4E-05	Respiratory epithelial adenoma, olfactory epithelial neuroblastoma	OEHHA (2005)
2	2-methylnaphthalene	-	Pulmonary alveolar proteinosis	IRIS (2003)	InI	-	-	Total lung tumors (adenomas or adenocarcinomas)	IRIS (2003)
3	Acenaphthylene	-		IRIS (1991a)	D	-	-	Skin tumor	IRIS (1991a)
4	Acenaphthene	-	Hepatotoxicity	IRIS (1990a)	D	3	-		IRIS (1990a)
5	Fluorene	-	Decreased red blood cells, packed cell volume and hemoglobin	IRIS (1990b)	D	3	-	Kidney tubular adenoma	IRIS (1990b)
6	Phenanthrene	-		IRIS (1990c)	D	3	-	Skin papillomas	IRIS (1990c)
7	Anthracene	-	Cellular necrosis	IRIS (1991b)	D	3	-	Skin tumor	IRIS (1991b)
8	Fluoranthene	-	Nephropathy, increased liver weights, hematological alterations, and clinical effects	IRIS (1990d)	D	3	-	Lung tumor	IRIS (1990d)
9	Pyrene	-	Kidney effects (renal tubular pathology, decreased kidney weights)	IRIS (1990e)	D	3	-	Mitotic gene conversion	IRIS (1990e)
10	Chrysene	-		IRIS (1990f)	B2	2B	6.0E-07	Liver tumors, malignant lymphoma, hepatic tumors and lung tumors	IRIS (1990f)
11	Benzo[c]phenanthrene	-			-	-	-		
12	Benzo(a)anthracene	-		IRIS (1990g)	B2	2B	6.0E-05	Pulmonary adenoma, hepatoma and liver adenomas	IRIS (1990g)
12	Cyclopenta[c,d]pyrene	-			-	-	-		
13	5-Methylchrysene	-		OEHHA (2004)	-	2B	6.0E-04	Liver and lung tumor	OEHHA (2004)
14	Benzo[b]fluoranthene	-		IRIS (1990h)	B2	2B	6.0E-05	Liver adenomas and hepatomas, lung adenomas	IRIS (1990h)
15	Benzo[k]fluoranthene	-		IRIS (1990i)	B2	2B	6.0E-06	Hepatic adenomas and hepatomas, lung adenomas	IRIS (1990i)
16	Benzo[j]aceanthrylene	-			-	-	-	Lung neoplams	NCBI (2020a)
16	Benzo[e]aceanthrylene	-			-	-	-		
17	Benzo[a]pyrene	2.0E-06	Developmental, immunological and reproductive effects	IRIS (2017)	CH	1	6.0E-04	Forestomach, liver, oral cavity, duodenum, and auditory canal tumors	IRIS (2017)
18	Benzo[e]pyrene	-			-	3	-	Skin tumours	IARC (1983)
19	Perylene	-			-	-	-		
20	Indeno[1,2,3-cd]pyrene	-			B2	2B	6.0E-05	Tumors and gene mutation	IRIS (1990j)
21	Dibenzo[a,h]anthracene	-			B2	2A	6.0E-04	Carcinomas, DNA damage and gene mutations	IRIS (1990k)
22	Benzo[g,h,i]perylene	-			D	3	-	Lung epidermoid tumors, papillomas and carcinomas	IRIS (1990m)
23	Dibenzo[a,l]pyrene	-	Atrophy	NCBI (2020b)	-	2A	6.0E-03	Adenocarcinoma, carcicoma	NCBI (2020b)
24	Dibenzo[a,e]pyrene	-			-	3	6.0E-04	Carcinoma, papilloma, sarcoma, skin neoplasms	NCBI (2020c)
25	Dibenzo[a,i]pyrene	-			-	2B	6.0E-03	Lung tumors	OEHHA (2005)
26	Dibenzo[a,h]pyrene	-			-	-	-	Lung tumors	OEHHA (2005)

Table S3. Occupational and residential characteristics of e-waste workers. Number of responses and percentage in parenthesis, unless otherwise indicated

	Burner	dismantlers	Sorters	Collector	P-value
Job Category	37(26.1)	78(54.9)	8(5.6)	19(13.4)	
Sleep location after work					0.042
On the site	20(54.1)	27(35.1)	5(71.4)	7(38.9)	
Off site, but within 1km of AG	16(43.2)	38(49.4)	2(28.6)	10(55.6)	
More than 1Km away	1(2.7)	12(15.6)	0(0)	1(5.5)	
Indoor cooking					0.273
Yes	4(10.8)	13(17.3)	3(37.5)	2(11.1)	
No	33(89.2)	62(82.7)	5(62.5)	16(88.9)	
years of working at the site, mean(SD)	7.8(5.7)	9.6(6.1)	11.3(6.2)	11.4(6.0)	0.157
Hours of work per day, mean(SD)	10(1.8)	9.5(2.6)	8.8(2.1)	9.1(3.0)	0.545
Days of work per week, mean(SD)	6.2(0.7)	5.7(1.3)	6.3(0.7)	6.1(0.6)	0.175
Doing other jobs alongside e-waste recycling					0.543
Yes	4(11.1)	13(17.1)	0(0.0)	3(15.8)	
No	32(88.9)	63(82.9)	8(100.0)	16(84.2)	
Previous job ever held for 6 months or more					0.969
Yes	17(47.2)	40(52.0)	4(50)	10(52.6)	
No	19(52.8)	37(48.1)	4(50)	9(47.4)	

Table S4. Worker classification and time spent in different activities by classification of e-waste workers.

Notes: (1) includes all workers; (2) includes only workers classified using stop-motion photography. Bottom portion applies only to 31 workers with filters analyzed for PAHs.

Worker Group	No. Workers (1)	No. Workers (2)	Time in different activities (min)																
			Burning	Dismantling	Collecting, sorting, loading	Buying, selling, weighing	Transporting materials	Other work	Motorbike or car	Bicycling	Walking	Non-work	Resting, Talking, Praying	Eat or drink	Tobacco use	Other (non-work)	Camera/Backpack Removed	Staging area	Total_time
All Workers																			
Burner	24	11	99	0	4	0	5	0	2	1	17	75	47	10	0	0	16	2	201
Dismantler	63	31	3	130	8	0	3	0	4	4	18	67	53	8	3	3	2	2	236
Collector	25	10	1	14	99	7	2	0	19	1	27	105	77	5	0	3	15	4	274
Trader	9	2	0	38	0	76	13	0	0	0	20	25	15	0	0	9	0	1	172
Transporter	8	8	2	2	8	5	69	2	29	13	15	102	62	10	19	4	23	3	247
Other	65	6	0	0	4	0	7	87	2	0	43	97	88	5	11	1	0	2	240
Motorbike/Ca	6	6	0	1	3	0	1	0	76	0	19	146	133	6	0	4	0	3	245
Bicycler	3	3	0	0	0	0	6	0	2	71	5	134	131	0	35	0	0	3	219
Walker	35	35	0	0	1	0	1	0	4	1	56	133	100	10	15	0	15	7	195
Not classified	139	59	1	2	1	0	0	0	2	1	10	143	101	2	2	2	35	3	161
Sum/Average	383	171	7	26	9	2	5	3	7	3	24	116	86	6	6	2	18	4	202
Workers with filters analyzed for PAHs																			
Burner		3	127	0	3	1	5	0	0	0	11	65	43	16	0	0	5	2	213
Dismantler		15	2	163	7	0	1	0	0	6	11	52	42	9	0	0	0	1	242
Collector		6	1	19	88	6	3	0	11	2	27	128	89	4	0	5	25	6	284
Trader		1	0	36	0	73	25	0	0	0	30	50	30	0	0	18	0	2	214
Other		2	0	0	11	0	22	71	0	0	61	92	83	4	0	3	0	2	256
Walker		2	0	0	3	0	6	0	0	17	41	140	126	13	0	0	0	2	206
Not classified		2	12	0	14	5	0	0	0	0	5	101	88	0	0	0	11	2	136
Sum/Average		31	14	84	23	4	4	5	2	4	20	79	62	8	0	2	6	2	238

Table S5. Gravimetric and adjusted optical PM concentrations ($\mu\text{g}/\text{m}^3$) at the e-w aste site (Agboglobshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile.

Measurement Type		Site			Agboglobshie - Round				Madina - Round			
		All	Ag	MD	1	2	3	4	1	2	3	4
Gravimetric PM2.5	NOBs	361	247	114	77	90	80	-	43	46	25	-
	Average	86	101	53	85	93	124	-	43	43	91	-
	St.Dev.	47	44	38	32	44	53	-	32	44	53	-
	Min	4	21	4	21	34	31	-	20	4	28	-
	10th	35	52	28	50	49	72	-	25	28	46	-
	25th	50	68	34	64	61	95	-	31	32	51	-
	50th	76	93	43	83	81	116	-	40	37	61	-
	75th	112	124	59	104	119	143	-	51	53	113	-
	90th	149	161	80	125	160	194	-	69	62	212	-
	95th	179	184	115	133	179	209	-	72	70	219	-
Max	292	292	221	168	206	292	-	81	115	221	-	
Adjusted Optical PM2.5	NOBs	428	290	138	91	99	91	9	44	49	35	10
	Average	96	107	74	133	88	108	44	54	54	134	49
	St.Dev.	70	66	73	89	35	72	34	89	35	72	34
	Min	23	28	23	61	28	34	28	31	35	23	24
	10th	39	52	31	73	45	57	29	39	40	28	24
	25th	51	76	41	87	65	82	33	43	44	33	26
	50th	83	99	49	111	86	105	40	49	50	49	33
	75th	118	122	61	132	107	132	46	61	54	261	46
	90th	157	155	178	193	131	158	61	80	63	302	76
	95th	206	180	268	280	146	161	73	84	79	322	124
Max	631	631	337	631	193	206	85	96	195	337	171	
Adjusted Optical PM10	NOBs	428	290	138	91	99	91	9	44	49	35	10
	Average	251	255	244	324	194	268	95	185	136	508	116
	St.Dev.	221	158	317	186	115	311	51	186	115	311	51
	Min	53	68	53	127	68	71	79	71	61	53	68
	10th	94	114	82	167	112	127	80	98	81	77	78
	25th	127	156	97	213	133	167	83	120	93	106	89
	50th	188	218	131	269	177	280	91	163	110	184	96
	75th	290	314	205	343	219	330	99	217	134	864	109
	90th	419	408	599	485	307	407	114	307	181	1162	143
	95th	680	483	1035	762	404	426	119	400	224	1578	225
Max	1693	1228	1693	1228	778	909	125	498	967	1693	308	

Table S6. Unadjusted optical PM concentrations ($\mu\text{g}/\text{m}^3$) at the e-waste site (Agboglobshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile.

Measurement Type		Site			Agboglobshie - Round				Medina - Round			
		All	Ag	MD	1	2	3	4	1	2	3	4
Unadjusted Optical PM1	NOBs	428	290	138	91	99	91	9	44	49	35	10
	Average	35	41	22	45	39	41	22	16	23	28	21
	St.Dev.	18	16	14	20	16	17	17	20	16	17	17
	Min	6	11	6	21	12	11	13	10	13	9	6
	10th	14	22	11	27	19	24	14	12	17	10	10
	25th	21	29	14	31	27	31	14	14	20	12	10
	50th	32	40	18	44	38	40	20	15	21	16	12
	75th	46	49	23	50	48	48	23	18	25	47	18
	90th	58	62	46	69	59	62	32	22	26	49	38
	95th	68	70	48	85	67	66	40	24	29	56	59
Max	112	112	99	112	83	74	48	28	99	71	79	
Unadjusted Optical PM2.5	NOBs	428	290	138	91	99	91	9	44	49	35	10
	Average	68	75	52	93	62	76	31	38	38	94	34
	St.Dev.	49	46	51	63	25	50	24	63	25	50	24
	Min	16	20	16	43	20	24	20	22	25	16	17
	10th	28	36	22	51	32	40	21	27	28	19	17
	25th	36	53	29	61	46	57	23	30	31	23	18
	50th	58	69	34	78	61	74	28	35	35	34	23
	75th	83	86	43	93	75	93	32	43	38	183	32
	90th	110	109	125	135	92	111	43	56	44	212	53
	95th	144	127	188	197	102	113	51	59	55	226	87
Max	443	443	236	443	136	145	60	68	137	236	120	
Unadjusted Optical PM4	NOBs	428	290	138	91	99	91	9	44	49	35	10
	Average	114	119	104	151	92	124	43	76	61	212	53
	St.Dev.	95	76	126	99	38	123	28	99	38	123	28
	Min	26	30	26	73	34	40	30	39	34	26	29
	10th	46	55	38	84	50	60	31	48	43	33	31
	25th	61	78	48	102	69	84	38	56	49	43	34
	50th	90	108	60	125	87	130	39	69	55	75	39
	75th	132	139	84	147	107	159	47	91	61	410	53
	90th	181	181	191	195	137	182	52	116	74	515	73
	95th	229	195	431	321	164	189	62	130	98	547	114
Max	725	725	645	725	266	221	71	171	231	645	155	
Unadjusted Optical PM10	NOBs	428	290	138	91	99	91	9	44	49	35	10
	Average	187	189	183	240	143	198	70	139	101	381	86
	St.Dev.	167	118	239	138	87	235	37	138	87	235	37
	Min	39	50	39	92	50	52	58	52	45	39	50
	10th	70	84	60	123	83	94	59	74	59	58	59
	25th	94	115	72	157	97	123	61	89	68	79	66
	50th	138	161	96	198	130	207	68	122	80	138	72
	75th	216	233	155	253	161	245	73	163	99	647	81
	90th	312	304	451	367	225	304	85	232	135	873	105
	95th	510	363	776	567	303	320	88	302	165	1194	165
Max	1281	906	1281	906	587	690	90	377	736	1281	225	

Table S7. Mean and median levels of PM2.5, PM10, PAH and PAH abundance by worker activities, all based on coded time lapse photos. Job_Avail_Categories (burner, dismantler, collector, trader, transporter, other) are mutually exclusive categories. Other activities are not mutually exclusive but require a minimum of 30 min.

Variable	Group	Statistic	Job_Avail_Burner	Job_Avail_Dismantler	Job_Avail_Collector	Job_Avail_Trader	Job_Avail_Transporter	Job_Avail_Other	Time_Burning	Time_Dismantling	Time_Collecting+sorting+loading	Time_Trading	Time_Transport_Materials	Time_Other_Work	Time_Motorbike or car	Time_Bicycling	Time_Walking	Time_Total_Non-work	Time_Non-work	Time_Eat+Drink	Time_Tobacco	Other (non-work)	Time_Backpack_Off	Staging area	Obs_Visible_Plume	Obs_Fire_Pit_10-30m	Obs_Fire_Pit_3-10m	Obs_Fire_Pit_1-3m	Obs_Fire_Pit_Cat	
PM2.5 Grav	Case	Mean	127	94	99	62	109	105	114	94	105	58	110	125	97	99	105	104	102	97	111	96	118	185	97	127	111	112	118	
		Median	124	88	85	56	108	91	103	95	91	95	8	108	109	80	91	108	96	92	96	106	96	109	185	87	117	110	98	109
		Count	12	48	19	7	6	58	6	28	9	1	8	6	12	8	46	117	98	7	10	2	21	1	12	9	3	6	18	
	Ref	Mean	99	103	101	102	100	99	102	105	102	103	102	102	103	103	101	95	104	103	102	103	100	102	103	101	102	102	100	
		Median	88	92	92	93	91	91	93	93	96	95	95	93	96	95	91	91	101	94	93	95	92	94	95	92	94	93	91	
		Count	188	152	181	193	194	142	137	115	134	142	135	137	131	135	97	26	45	136	133	141	122	142	131	134	140	137	125	
	Test	t-test	0.06	0.18	0.86	0.00	0.63	0.40	0.56	0.12	0.86	-	0.59	0.41	0.64	0.75	0.61	0.23	0.80	0.59	0.49	0.66	0.17	-	0.65	0.03	0.71	0.64	0.07	
		M-W	0.03	0.53	0.62	0.00	0.51	0.85	0.49	0.70	0.88	0.20	0.47	0.41	0.54	0.98	0.28	0.66	0.48	0.96	0.35	0.96	0.12	0.12	0.69	0.02	0.56	0.59	0.03	
	PM2.5 Optical	Case	Mean	168	113	112	82	97	101	210	121	119	82	96	106	82	89	117	112	107	166	108	125	113	123	149	96	185	182	156
			Median	109	105	104	77	85	90	109	107	112	76	87	98	78	86	112	99	99	101	105	121	99	123	132	99	100	109	106
Count			20	51	22	8	6	62	12	34	14	3	8	6	13	9	56	137	111	9	10	3	23	2	17	9	4	12	25	
Ref		Mean	107	112	112	113	113	116	108	114	115	116	117	116	119	117	115	132	132	113	116	116	116	116	112	117	114	111	109	
		Median	100	98	101	102	101	103	100	98	100	101	102	101	104	103	93	104	104	101	101	101	102	101	98	103	102	100	98	
		Count	207	176	205	219	221	165	156	134	154	165	160	162	155	159	112	31	57	159	158	165	145	166	151	159	164	156	143	
Test		t-test	0.12	0.88	0.99	0.01	0.17	0.07	0.13	0.65	0.76	0.07	0.04	0.58	0.00	0.01	0.89	0.29	0.10	0.40	0.40	0.41	0.80	0.94	0.16	0.01	0.49	0.24	0.14	
		M-W	0.34	0.45	0.26	0.05	0.64	0.16	0.40	0.20	0.15	0.22	0.55	0.98	0.02	0.25	0.03	0.40	0.27	0.41	0.54	0.20	0.58	0.99	0.01	0.56	0.63	0.53	0.30	
PM10 Optical		Case	Mean	372	262	281	207	305	233	429	310	302	229	288	377	233	228	278	259	255	350	249	327	225	321	352	193	347	385	321
			Median	242	245	220	198	292	188	256	277	315	133	290	294	194	210	266	218	214	208	230	336	194	321	334	180	230	232	205
	Count		20	51	22	8	6	62	12	34	14	3	8	6	13	9	56	137	111	9	10	3	23	2	17	9	4	12	25	
	Ref	Mean	254	265	263	267	264	277	259	262	268	272	270	267	274	274	268	324	303	267	273	270	279	271	262	276	269	263	263	
		Median	222	219	228	228	222	239	228	214	225	228	228	228	238	239	221	259	256	228	228	228	228	228	220	240	228	228	239	
		Count	207	176	205	219	221	165	156	134	154	165	160	162	155	159	112	31	57	159	158	165	145	166	151	159	164	156	143	
	Test	t-test	0.12	0.89	0.64	0.14	0.36	0.04	0.17	0.13	0.32	0.70	0.66	0.32	0.23	0.21	0.71	0.09	0.12	0.47	0.44	0.07	0.05	0.58	0.08	0.00	0.63	0.30	0.35	
		M-W	0.21	0.41	0.69	0.20	0.16	0.02	0.39	0.02	0.09	0.48	0.30	0.25	0.46	0.60	0.17	0.05	0.14	0.49	0.93	0.15	0.19	0.33	0.01	0.13	0.77	0.74	0.92	
	PAH Sum	Case	Mean	194	82	67	108	-	468	194	84	70	108	-	111	83	70	98	84	84	86	-	51	43	-	100	66	-	158	140
			Median	112	87	75	108	-	108	112	88	75	108	-	111	83	76	103	83	83	86	-	51	43	-	100	66	-	89	104
Count			3	14	5	1	0	3	3	18	7	1	0	2	1	3	8	19	17	2	0	1	1	0	2	1	0	4	6	
Ref		Mean	124	171	143	131	131	94	124	194	148	131	131	132	132	137	142	205	187	134	131	133	133	131	133	133	131	126	128	
		Median	88	102	94	88	88	87	88	102	94	88	88	88	91	94	85	91	91	88	88	91	91	88	88	91	88	88	88	
		Count	28	17	26	30	31	28	28	13	24	30	31	29	30	28	23	12	14	29	31	30	30	31	29	30	31	27	25	
Test		t-test	0.58	0.20	0.10	-	-	0.41	0.58	0.23	0.12	-	-	0.61	-	0.12	0.39	0.23	0.23	0.30	-	-	-	-	0.42	-	-	0.74	0.86	
		M-W	0.32	0.20	0.05	0.37	-	0.05	0.32	0.34	0.05	0.37	-	0.15	0.74	0.16	0.16	0.44	0.55	0.87	-	0.22	0.12	-	0.47	0.31	-	0.81	0.37	
PAH Abund		Case	Mean	1175	944	713	1858	-	803	1175	947	602	1858	-	1266	1050	1020	1051	909	978	525	-	320	471	-	328	721	-	962	949
			Median	1232	857	486	1858	-	793	1232	857	471	1858	-	1266	1050	959	904	801	849	525	-	320	471	-	328	721	-	976	925
	Count		3	14	5	1	0	3	3	18	7	1	0	2	1	3	8	19	17	2	0	1	1	0	2	1	0	4	6	
	Ref	Mean	935	970	1005	928	958	975	935	974	1062	928	958	937	955	952	926	1036	934	988	958	980	974	958	1002	966	958	958	960	
		Median	857	959	909	857	864	909	857	959	957	857	864	864	857	857	864	1035	909	955	864	909	909	864	955	909	864	864	864	
		Count	28	17	26	30	31	28	28	13	24	30	31	29	30	28	23	12	14	29	31	30	30	31	29	30	31	27	25	
	Test	t-test	0.44	0.88	0.16	-	-	0.36	0.44	0.89	0.02	-	-	0.72	-	0.83	0.63	0.46	0.80	0.21	-	-	-	-	0.00	-	-	0.99	0.96	
		M-W	0.32	0.91	0.31	0.12	-	0.55	0.32	0.90	0.03	0.12	-	0.57	0.65	0.74	0.75	0.33	0.94	0.17	-	0.12	0.26	-	0.04	0.58	-	0.95	0.96	

Table S8. PAH concentrations (total, low and high molecular weight) concentrations (ng/m³) at the e-waste site (Agbogbloshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile.

Measurement Type		Site			Agbogbloshie - Round				Madina - Round			
		All	Ag	MD	1	2	3	4	1	2	3	4
Sum PAHs All	NOBs	34	24	10	10	14	-	-	5	5	-	-
	Average	83	86	75	73	95	-	-	70	80	-	-
	St.Dev.	26	25	29	20	28	-	-	20	28	-	-
	Min	34	34	42	34	43	-	-	42	49	-	-
	10th	46	48	48	43	62	-	-	51	50	-	-
	25th	65	73	54	67	86	-	-	65	51	-	-
	50th	84	88	68	75	100	-	-	70	61	-	-
	75th	101	103	93	87	111	-	-	73	107	-	-
	90th	117	117	110	95	120	-	-	89	122	-	-
	95th	121	120	121	98	121	-	-	95	127	-	-
Max	132	123	132	100	123	-	-	100	132	-	-	
SUM PAHs Low Molecular Weight	NOBs	34	24	10	10	14	-	-	5	5	-	-
	Average	66	68	61	57	77	-	-	55	68	-	-
	St.Dev.	25	24	26	16	27	-	-	16	27	-	-
	Min	25	25	36	25	27	-	-	37	36	-	-
	10th	37	37	37	36	45	-	-	41	36	-	-
	25th	49	59	40	45	63	-	-	47	37	-	-
	50th	64	67	56	61	78	-	-	57	55	-	-
	75th	85	86	68	67	97	-	-	63	98	-	-
	90th	100	99	100	70	103	-	-	67	108	-	-
	95th	107	104	107	79	107	-	-	68	111	-	-
Max	114	111	114	87	111	-	-	69	114	-	-	
SUM PAHs High Molecular Weight	NOBs	34	24	10	10	14	-	-	5	5	-	-
	Average	17	18	14	17	19	-	-	15	12	-	-
	St.Dev.	9	9	7	11	7	-	-	11	7	-	-
	Min	5	6	5	6	9	-	-	5	6	-	-
	10th	7	8	6	7	12	-	-	7	7	-	-
	25th	10	13	9	8	15	-	-	10	9	-	-
	50th	15	16	13	14	17	-	-	13	14	-	-
	75th	19	21	17	19	21	-	-	18	14	-	-
	90th	27	27	20	27	27	-	-	25	17	-	-
	95th	31	32	25	36	30	-	-	28	17	-	-
Max	45	45	31	45	33	-	-	31	18	-	-	

Table S9. Abundances PAH concentrations (total, low and high molecular weight) concentrations (ng/m³) at the e-waste site (Agbogbloshie) and reference sites (Madina) by sampling round. NOBs is number of observations. 10th to 95th is percentile.

Measurement Type		Site			Agbogbloshie - Round				Madina - Round			
		All	Ag	MD	1	2	3	4	1	2	3	4
Sum PAHs All	NOBs	34	24	10	10	14	-	-	5	5	-	-
	Average	1380	1079	2102	1000	1135	-	-	2035	2168	-	-
	St.Dev.	861	451	1174	763	951	-	-	763	951	-	-
	Min	396	396	754	396	471	-	-	1017	754	-	-
	10th	616	568	957	688	568	-	-	1087	844	-	-
	25th	815	781	1061	817	737	-	-	1194	979	-	-
	50th	1050	981	1834	979	1004	-	-	2092	1577	-	-
	75th	1576	1528	3061	1129	1570	-	-	2689	3731	-	-
	90th	2510	1719	3738	1528	1835	-	-	2987	3772	-	-
	95th	3376	1846	3769	1528	1896	-	-	3086	3786	-	-
Max	3800	1967	3800	1528	1967	-	-	3185	3800	-	-	
SUM PAHs Low Molecular Weight	NOBs	34	24	10	10	14	-	-	5	5	-	-
	Average	1127	872	1739	793	928	-	-	1605	1874	-	-
	St.Dev.	773	443	1050	621	889	-	-	621	889	-	-
	Min	294	294	546	329	294	-	-	869	546	-	-
	10th	443	407	695	429	417	-	-	883	612	-	-
	25th	599	521	878	493	550	-	-	903	712	-	-
	50th	836	786	1615	775	786	-	-	1805	1425	-	-
	75th	1416	1254	2401	1014	1348	-	-	1867	3275	-	-
	90th	1852	1467	3289	1247	1615	-	-	2294	3357	-	-
	95th	2823	1639	3350	1318	1717	-	-	2436	3384	-	-
Max	3411	1816	3411	1389	1816	-	-	2579	3411	-	-	
SUM PAHs High Molecular Weight	NOBs	34	24	10	10	14	-	-	5	5	-	-
	Average	253	207	362	207	207	-	-	431	294	-	-
	St.Dev.	151	78	222	200	98	-	-	200	98	-	-
	Min	67	67	114	67	91	-	-	114	152	-	-
	10th	117	102	148	86	133	-	-	183	174	-	-
	25th	178	170	223	151	178	-	-	287	208	-	-
	50th	220	194	303	209	193	-	-	324	267	-	-
	75th	286	247	475	263	240	-	-	607	319	-	-
	90th	365	292	628	303	277	-	-	736	443	-	-
	95th	553	351	725	332	311	-	-	779	484	-	-
Max	822	367	822	361	367	-	-	822	525	-	-	

Table S10. Summary of PAH concentrations in personal samples (top) and PAH abundances (bottom). AG = Agboghloshie; MD = Madaina. Statistically significant differences between sites highlighted in yellow for P<0.10 and in pink for P<0.05.

Site	Statistic	Naphthalene	2-methylnaphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo[c]phenanthrene	Benzo[a]anthracene	Chrysene	5-Methylchrysene	Benzo[b]fluoranthene	Benzo[k]fluoranthene	Benzo[j]aceanthrylene	Benzo[e]pyrene	Benzo[a]pyrene	Perylene	Indeno[1,2,3-cd]pyrene	Dibenz[a,h]anthracene	Benzo[g,h,i]perylene	Dibenz[a,l]pyrene	Dibenz[a,e]pyrene	Dibenz[a,i]pyrene	Dibenz[a,h]pyrene	Sum_PAH	Sum_PAH_LMW	Sum_PAH_HMW	
Concentration (ng/g)																															
All	NOBs	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
	Det.Freq (%)	100	100	41	41	100	100	32	100	100	68	62	97	3	97	88	100	85	76	35	74	100	76	38	12	0	0	-	-	-	
	Mean	35.0	3.3	0.4	1.3	2.5	16.1	0.1	3.8	1.9	0.3	0.2	1.6	0.1	1.3	0.6	2.5	0.7	0.5	0.5	2.0	3.1	1.8	0.8	0.6	1.0	0.9	82.9	66.3	16.5	
	SD	23.2	1.6	0.4	1.5	1.5	6.1	0.1	1.3	1.1	0.2	0.1	0.4	0.1	0.9	0.5	0.7	0.6	1.0	2.3	2.4	1.8	1.0	0.4	0.1	0.1	26.2	24.6	8.5		
	Minimum	3.8	1.1	0.0	0.1	0.4	8.1	0.1	1.5	0.2	0.0	0.0	0.0	0.0	0.1	0.0	1.3	0.0	0.0	0.0	0.1	0.2	0.1	0.1	0.3	0.7	0.6	34.1	24.7	4.6	
	25th Per	18.4	2.0	0.0	0.2	1.4	11.0	0.1	3.0	1.2	0.0	0.0	1.4	0.0	0.8	0.3	2.1	0.3	0.1	0.3	0.9	0.4	0.2	0.4	0.9	0.9	65.4	49.4	10.3		
	Median	29.9	3.0	0.1	0.2	2.3	15.7	0.1	3.6	1.8	0.3	0.1	1.6	0.0	1.1	0.5	2.5	0.6	0.6	0.1	0.8	2.6	1.0	0.2	0.4	1.0	0.9	84.1	63.6	15.2	
	75th Per	57.0	4.1	0.7	2.7	3.4	19.7	0.2	4.6	2.6	0.4	0.2	1.8	0.0	1.7	0.9	3.0	1.1	0.7	0.7	3.1	4.8	3.2	1.3	0.6	1.1	1.0	101.3	84.6	18.8	
	90th Per	68.7	5.7	1.1	3.8	4.9	24.5	0.2	5.6	3.3	0.5	0.3	2.1	0.0	2.4	1.2	3.4	1.4	0.8	1.1	5.1	6.2	4.4	2.1	0.9	1.1	1.0	117.0	99.6	27.0	
	Maximum	82.8	6.7	1.2	4.8	5.6	30.2	0.4	6.7	4.5	0.6	0.5	2.7	0.5	3.9	2.3	4.3	2.8	1.3	4.2	9.4	8.4	7.0	4.5	2.3	1.1	1.1	132.4	114.1	45.3	
AG	Mean	36.9	3.3	0.4	1.4	2.5	15.9	0.1	3.8	2.0	0.3	0.2	1.7	0.1	1.4	0.6	2.6	0.9	0.6	0.5	2.3	2.8	2.2	1.0	0.7	1.0	1.0	86.1	68.4	17.7	
	Median	30.8	3.0	0.1	0.2	2.2	14.7	0.1	3.8	2.0	0.3	0.2	1.6	0.0	1.2	0.4	2.6	0.7	0.6	0.1	1.1	2.2	2.0	0.2	0.5	1.0	1.0	88.4	66.9	15.7	
	Count	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
MD	Mean	30.3	3.2	0.3	1.3	2.6	16.6	0.1	3.7	1.7	0.2	0.1	1.3	0.0	1.0	0.6	2.4	0.5	0.3	0.6	1.0	3.8	0.8	0.4	0.4	0.9	0.9	75	61	14	
	Median	25.8	3.1	0.1	0.2	2.8	19.4	0.1	3.5	1.3	0.3	0.0	1.3	0.0	0.8	0.5	2.3	0.3	0.2	0.1	0.1	3.8	0.3	0.2	0.4	0.9	0.9	68	56	13	
	Count	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
P-value	t-test	0.48	0.95	0.31	0.87	0.97	0.73	0.54	0.75	0.49	0.40	0.12	0.07	0.26	0.13	0.87	0.46	0.07	0.01	0.90	0.10	0.35	0.02	0.10	0.06	0.07	0.07	0.31	0.48	0.19	
	M-W	0.52	0.91	0.31	0.57	0.91	0.57	0.15	0.73	0.34	0.23	0.10	0.04	0.04	0.29	0.68	0.52	0.03	0.03	0.04	0.01	0.50	0.01	0.05	0.03	0.04	0.04	0.17	0.31	0.12	
Abundance (ug/g)																															
All	NOBs	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	
	Mean	610	55	6	24	41	265	2	62	31	5	2	25	1	19	10	41	10	8	9	25	54	23	10	9	16	16	1380	1127	253	
	SD	568	41	8	36	33	156	1	38	25	4	3	12	1	14	10	22	8	5	21	30	63	23	12	5	8	8	861	773	151	
	Minimum	41	6	0	1	5	67	0	15	2	0	0	2	0	1	1	7	0	1	1	2	2	2	1	2	5	5	396	294	67	
	25th Per	204	26	1	3	17	173	1	37	16	1	1	19	0	11	3	28	6	3	1	4	15	7	3	6	10	10	815	599	178	
	Median	400	44	1	4	35	225	2	55	20	4	2	22	1	15	6	37	9	8	1	14	29	13	5	8	14	14	1050	836	220	
	75th Per	871	68	8	32	47	318	2	71	46	7	3	28	1	25	14	51	13	10	6	32	76	34	15	10	19	19	1576	1416	286	
	90th Per	1262	115	17	60	87	476	4	114	60	9	4	37	1	38	17	60	21	12	17	57	113	51	23	14	26	25	2510	1852	365	
	Maximum	2527	166	36	168	137	705	6	194	128	16	14	58	8	60	47	105	39	20	114	151	275	113	57	23	45	43	3800	3411	822	
AG	Mean	481	41	5	17	31	196	2	48	25	4	2	21	1	16	7	33	10	7	6	25	34	24	10	8	13	12	1079	872	207	
	Median	385	41	1	4	32	207	2	46	18	4	2	21	0	15	5	31	9	8	1	16	25	19	5	7	12	12	981	786	194	
	Count	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
MD	Mean	918	90	8	39	65	430	3	98	48	7	3	33	1	27	15	62	12	8	16	25	102	21	11	12	25	24	2102	1739	362	
	Median	716	82	2	7	52	378	2	97	42	7	1	30	1	18	13	55	6	6	1	6	92	8	5	10	23	22	1834	1615	303	
	Count	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Tests	t-test	0.14	0.02	0.51	0.28	0.05	0.00	0.04	0.01	0.08	0.17	0.50	0.06	0.57	0.15	0.12	0.00	0.52	0.78	0.43	0.97	0.05	0.79	0.82	0.04	0.00	0.00	0.02	0.03	0.06	
	M-W	0.21	0.01	0.21	0.14	0.05	0.00	0.04	0.00	0.06	0.13	0.57	0.01	0.00	0.26	0.10	0.00	0.85	0.85	0.38	0.11	0.04	0.08	0.65	0.01	0.00	0.00	0.01	0.01	0.03	

Table S11. Comparison of PM associated PAHs concentrations from other e-waste and urban studies.

Author(s) (year)	Country of study	Type of monitoring	Number of monitoring site or participants	Number of PAH analyzed	Study Location	Total PAH mean/ mean range concentration	Total PAH median concentration	PAH with highest concentration
(Deng et al., 2006)	China	Fixed site monitoring	1 site	16 PAH	e-waste site	148 ng/m ³ (TSP) 102 ng/m ³ (PM _{2.5})		Benzo[b] or [k] fluoranthene
(Gu et al., 2009)	China	Fixed site	2 sites	21 PAH	E-waste dismantling area Urban site	134 ng/m ³ (PM _{2.5}) 71 ng/m ³ (PM _{2.5})		Benzo[b+k]fluoranthene
(Luo, Bao, Li, & Zeng, 2015)	China	Fixed site	2 sites	16 PAH	e-waste site urban site	15 –18 ng/m ³ 6–7 ng/m ³		benzo[g,h,i]perylene
(Chen et al., 2016)	China	Fixed site Monitoring	2 sites	16 PAHs	e-waste site urban site	28 ng/m ³ 19 ng/m ³	18 ng/m ³ 14 ng/m ³	dibenzo[a,e]pyrene
(Chen et al., 2019)	China	Fixed site	4 sites	16 PAH	e-waste dismantling area 3 urban sites	16 ng/m ³ (TSP),15 ng/m ³ (PM ₁₀) 15 ng/m ³ (PM _{2.5}) 3-8 ng/m ³ (TSP),3-7 ng/m ³ (PM ₁₀), 2-6 ng/m ³ (PM _{2.5})		Pyrene fluoranthene
(Zeng et al., 2020)	China	Fixed site	2 sites	16 PAHs	E-waste site Urban site		7ng/m ³ (PM _{2.5}) 2 ng/m ³ (PM _{2.5})	NS
(Andreou & Rapsomanikis, 2009)	Greece	Fixed site	2 monitoring sites	15 PAH	Urban city	28-29 ng/m ³ (PM _{2.5}), 0.4-0.5 ng/m ³ (PM _{10- 2.5})		Benzo[g,h,i]perylene Benzo[b]fluoranthene Fluoranthene
(Shi et al., 2010)	China	Fixed site	6 sites	17 PAH	6 urban cities	56-195 ng/m ³ (PM ₁₀)		benzo[a]anthracene benzo[b]fluoranthene

								fluoranthene
(Zhu et al., 2011)	USA	Fixed site and personal monitoring	2 site and 107 participants	16 PAH	Urban cities		42-44 ng/m ³ (Fixed), 98-120 ng/m ³ (Personal)	naphthalene fluorene
(Mohanraj, Dhanakumar, & Solaraj, 2012)	India	Fixed site				263 ng/m ³ (PM _{2.5})		Chrysene
(Liu et al., 2015)	China	Fixed site	1 site	16 PAH	Urban city	34 ng/m ³ (PM _{2.5})		Benzo(a)pyrene
(Mo et al., 2019)	China	Fixed site	5 sites	16 PAHs	5 Urban cities	8-18 ng/m ³ (PM _{2.5})		NS
(Zioła & Słaby, 2020)	Poland	Fixed site	1 site	16 PAH	1 urban-industrial area	60 ng/m ³ (PM ₁₀)		phenanthrene
(Klánová et al., 2009)	Ghana	Fixed site	2 sites	16 PAH	2 urban cities	1950 -3380 ng/sample		NS
(Bortey-Sam et al., 2015)	Ghana	Fixed site	2 sites	21 PAH	2 urban cities	3-30 ng/m ³	2.6 -30 ng/m ³	Phenanthrene Benzzo[g,h,i]perylene
(Safo-Adu, Ofosu, Carboo, & Serfor-Armah, 2014)	Ghana	Fixed site	1 site	20 PAH	1 urban city	810 ng/m ³		Pyrene anthanthene
(Palm, Dampare, Blankson-arthur, Adu-kumi, & Aboh, 2019)	Ghana	Fixed site	1 site	16 PAH	1 semi-urban	BDL- 8.4 ng/m ³		naphthalene Phenanthrene Fluoranthene

Note: NS= Not stated and BDL = below detection

