

An Investigation into the Effect of Emissions from Industrial Complexes on Air Quality in the Ulsan Metropolitan City Utilizing Trace Components in PM2.5

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Table S1. Annual average concentrations of particulate matter with an aerodynamic diameter $\leq 2.5 \mu\text{m}$ (PM2.5) and particulate matter with an aerodynamic diameter $\leq 10 \mu\text{m}$ (PM10) according to wind direction (degree) (Unit: $\mu\text{g}/\text{m}^3$).

Wind Direction		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5
PM2.5	Average	16.1	15.7	14.3	13.7	15.5	18.6	24.1	24.2	18.5	15.6	19.8	21.2	20.1	18.9	19.0	18.3
	Standard Deviation	12.4	12.3	10.6	10.8	11.7	12.9	12.6	12.1	12.1	10.7	12.6	13.5	12.5	12.5	13.2	13.5
	Number	856	513	244	285	315	175	355	281	225	503	282	150	282	743	1330	1530
PM10	Average	28.3	27.8	26.7	26.8	27.6	33.2	43.0	41.8	32.9	30.2	35.8	39.7	35.3	33.3	32.5	31.0
	Standard Deviation	19.5	17.8	18.0	17.9	17.0	19.0	22.6	19.6	20.1	18.2	21.2	27.6	20.2	19.7	20.8	20.9
	Number	867	522	247	294	325	180	355	282	223	506	285	151	284	745	1335	1553

Table S2. Mean concentrations of PM10 and PM2.5 and the mass concentrations of PM2.5 components, obtained from hourly data in Ulsan.

		PM _{2.5} PM ₁₀		Ions (μg/m ³)						Carbon (μg/m ³)		Elements (ng/m ³)									
				SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	Na ⁺	NH ₄ ⁺	Ca ²⁺	OC	EC	K	Ti	V	Mn	Fe	Ni	Zn	As	Pb	
2017	DJF	20.1	32.0	1.91	2.90	0.21	0.13	1.51	0.03	2.51	0.58	205	6.31	1.84	13.6	154	1.13	46.3	2.74	15.0	
	MAM	21.3	41.0	2.68	2.72	0.20	0.13	1.76	0.06	3.40	0.65	208	15.21	10.45	19.7	248	3.89	68.5	6.72	21.1	
	JJA	14.1	25.4	4.00	1.40	0.17	0.22	1.96	0.03	2.58	0.57	82	8.57	13.45	17.7	159	4.64	72.9	6.10	16.9	
	SON	18.3	30.7	2.47	1.66	0.22	0.18	1.29	0.07	3.13	0.69	174	6.90	4.47	15.6	177	1.91	53.3	3.41	12.8	
	Yearly	18.5	32.4	2.67	2.26	0.20	0.16	1.62	0.05	2.91	0.62	170	9.31	7.39	16.6	186	2.85	59.9	4.72	16.5	
OC: organic carbon; EC: elemental carbon; DJF: December/January/February (winter); MAM: March/April/May (Spring); JJA: June/July/August (Summer); SON: September/October/November (Fall)																					

Table S3. Annual average concentrations of vanadium (V) in PM2.5 according to wind direction (degree) (Unit: $\mu\text{g}/\text{m}^3$).

Wind Direction		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5
V	Average	3.60	3.51	3.88	4.87	4.97	15.75	32.03	26.55	16.68	8.01	7.62	7.52	5.29	3.20	3.25	3.37
	Standard Deviation	9.57	6.71	9.52	10.93	8.35	24.60	29.39	25.65	24.19	9.85	10.78	16.90	7.71	6.19	7.03	10.11
	Number	814	477	222	276	301	173	316	258	210	429	272	145	266	703	1269	1487

Table S4. Number of cases for each season according to wind direction (degree) (Unit: m/s^3).

Wind Direction		0	22.5	45	67.5	90	112.5	135	157.5	180	202.5	225	247.5	270	292.5	315	337.5	ND
DJF	ALL	170	69	28	29	26	18	23	23	23	69	45	36	75	376	604	467	2081
	SC	5	5	3	1	2	2	4	1	1	3	1	0	1	21	22	10	7
MAM	ALL	166	132	63	73	79	69	148	114	85	170	93	57	95	177	263	299	2083
	SC	10	9	5	6	6	18	81	49	20	15	9	5	9	9	26	18	30
JJA	ALL	199	143	74	112	153	65	155	116	89	222	92	34	77	85	184	286	2086

	SC	18	8	6	5	5	14	88	49	22	27	8	3	8	9	13	25	54
SON	ALL	348	191	88	84	77	31	33	37	31	57	61	25	41	117	305	536	2062
	SC	9	9	3	8	9	5	13	9	4	3	3	2	2	4	15	20	20

N.D.: Wind direction could not be specified.

Table S5. Mass concentrations of PM10 and components in PM2.5, obtained from hourly data in Ulsan for selected cases (SC).

		PM _{2.5}	PM ₁₀	Ions (µg/m ³)						Carbon (µg/m ³)		Elements (ng/m ³)								
				SO ₄ ²⁻	NO ₃ ⁻	Cl ⁻	Na ⁺	NH ₄ ⁺	Ca ²⁺	OC	EC	K	Ti	V	Mn	Fe	Ni	Zn	As	Pb
	DJF	25.1	38.7	3.21	2.95	0.21	0.15	2.11	0.03	2.86	0.71	220	20.7	34.6	70.6	369	12.5	123	18.5	39.0
	MAM	27.0	50.7	4.46	3.61	0.47	0.17	2.63	0.05	4.21	1.01	177	25.2	51.2	44.5	340	16.7	138	18.7	45.2
SC	JJA	27.0	42.8	6.38	2.88	0.33	0.24	3.29	0.04	4.32	1.03	134	27.0	57.8	50.5	308	18.1	183	17.4	51.5
	SON	23.9	35.8	3.13	1.96	0.24	0.20	1.63	0.09	4.30	1.08	157	15.9	45.0	47.9	307	14.4	147	15.4	44.3
	Yearly	26.3	44.1	4.97	3.05	0.36	0.20	2.73	0.05	4.10	1.00	157	24.9	53.3	47.9	323	17.0	158	17.8	47.7

OC: organic carbon; EC: elemental carbon; DJF: December/January/February (winter); MAM: March/April/May (Spring); JJA: June/July/August (Summer); SON: September/October/November (Fall)

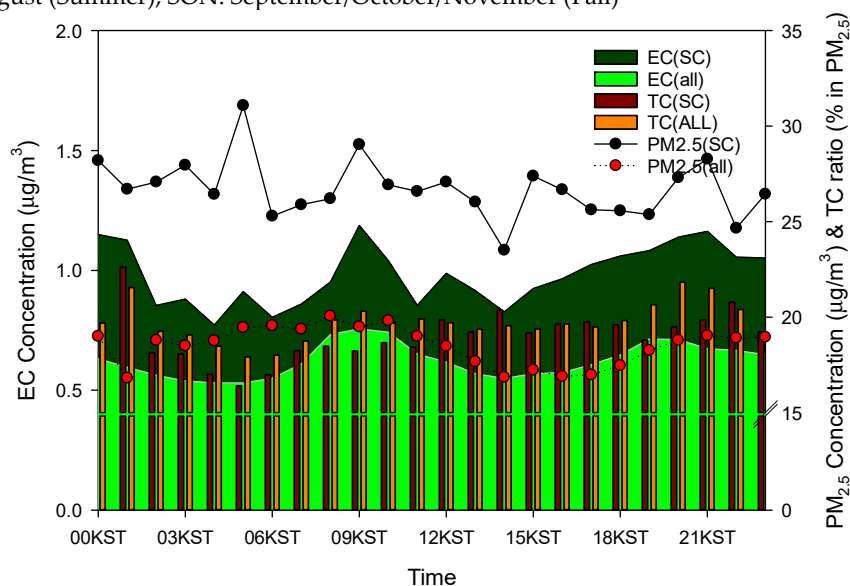


Figure S1. Diurnal changes in the concentration of PM2.5, and the ratio of total carbon (TC; OC+EC) to PM2.5 in SCs.

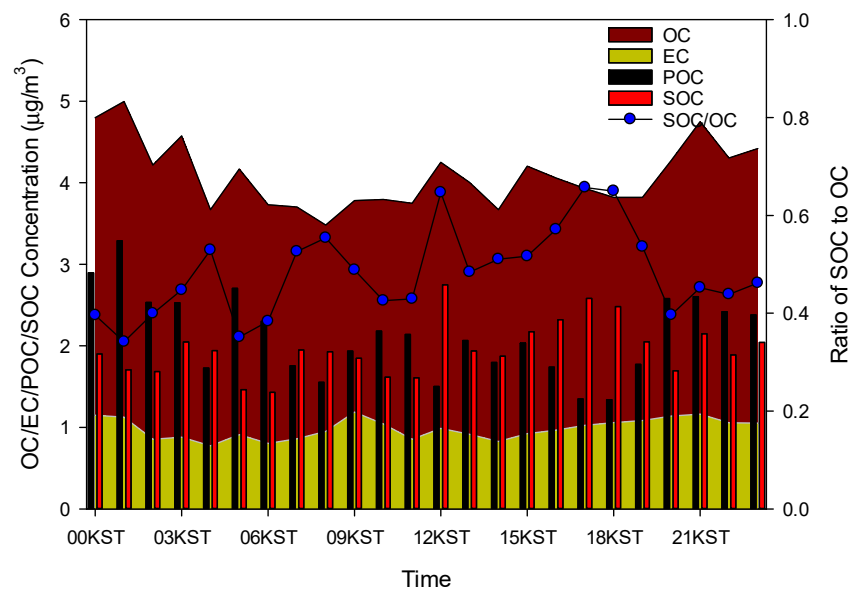


Figure S2. Diurnal change in the concentration of organic carbon (OC), element carbon (EC), primary organic carbon (POC), secondary organic carbon (SOC), and the ratio of SOC to OC in SCs.