Measurement on PM and its chemical compositions for real-world emissions from non-road and on-road diesel vehicles

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Supplementary Materials:

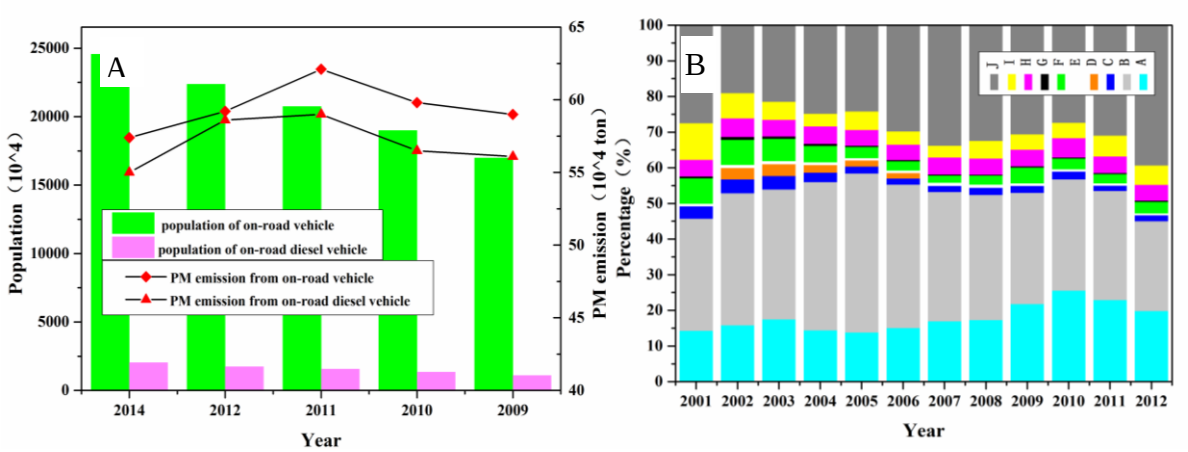

Figure S1 Population and PM emission from on-road trucks (A); population percentages of each types of construction equipment (A, B, C, D, E, F, G, H, I, J represent excavator, loader, bulldozer, concrete mixer, leveler, roller, paver, construction crane, tower crane, forklift, respectively.) (B).

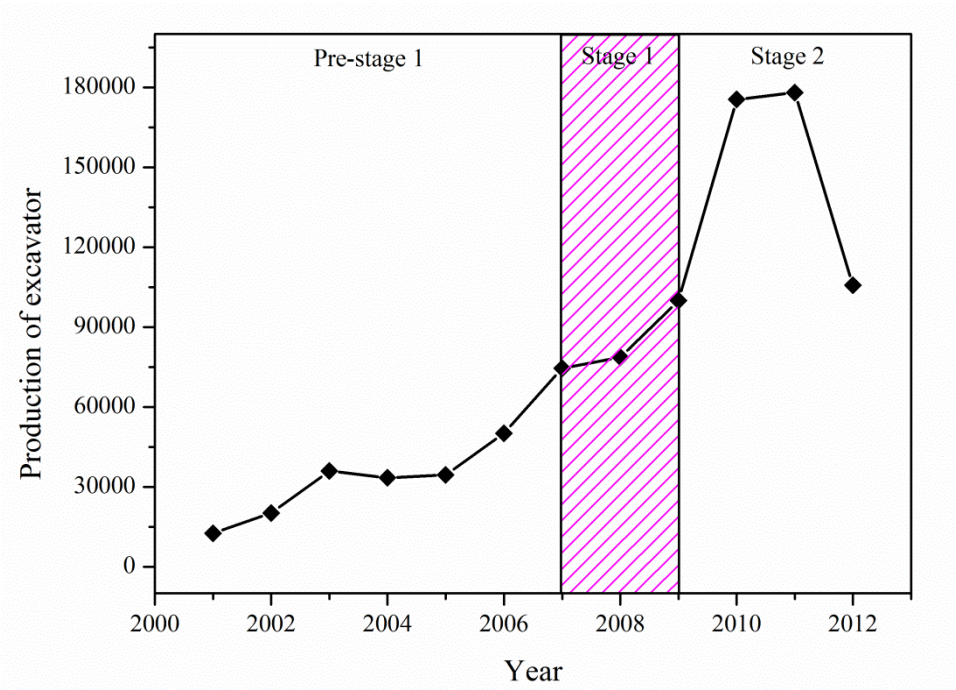

Figure S2 Annual productions of excavators in China

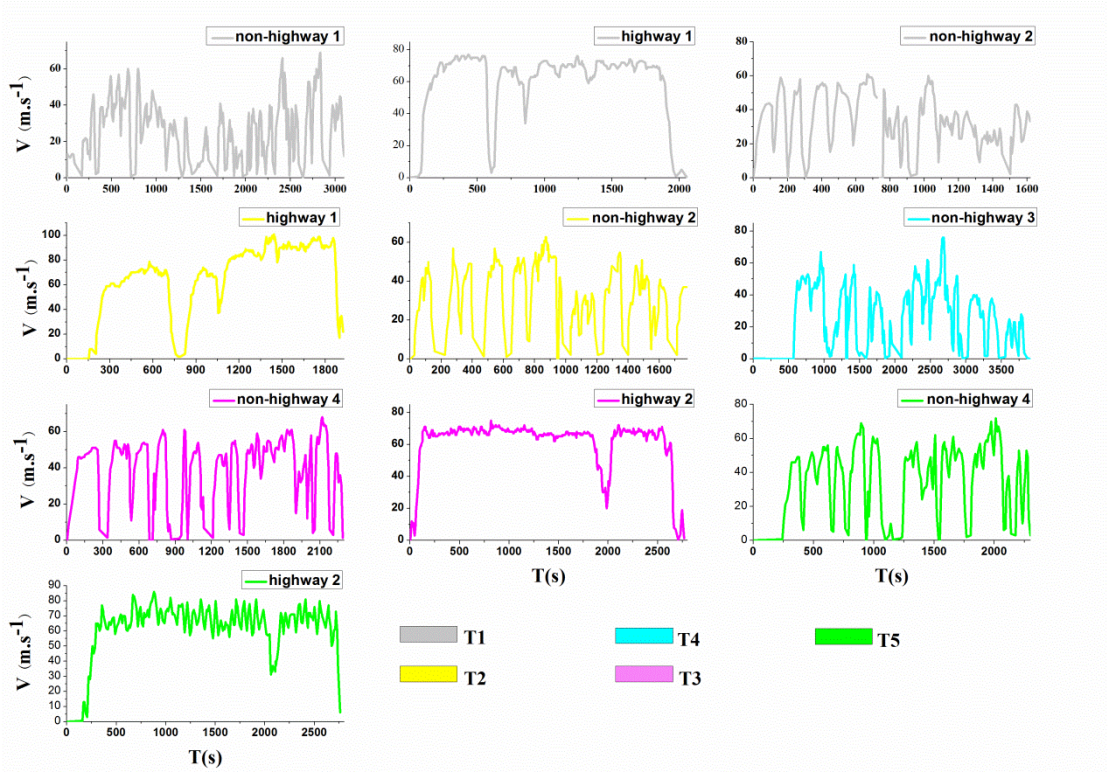

Figure S3 Velocity profiles of diesel trucks under different roads

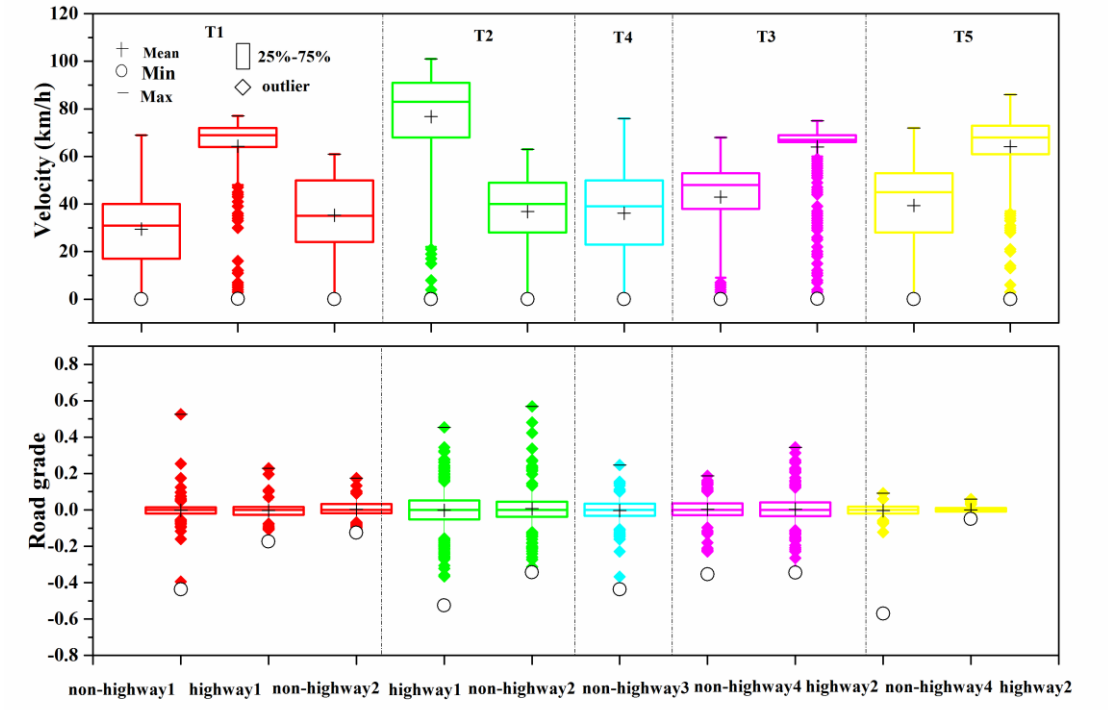

Figure S4 Box plots of velocity and road grade for different trucks under different roads

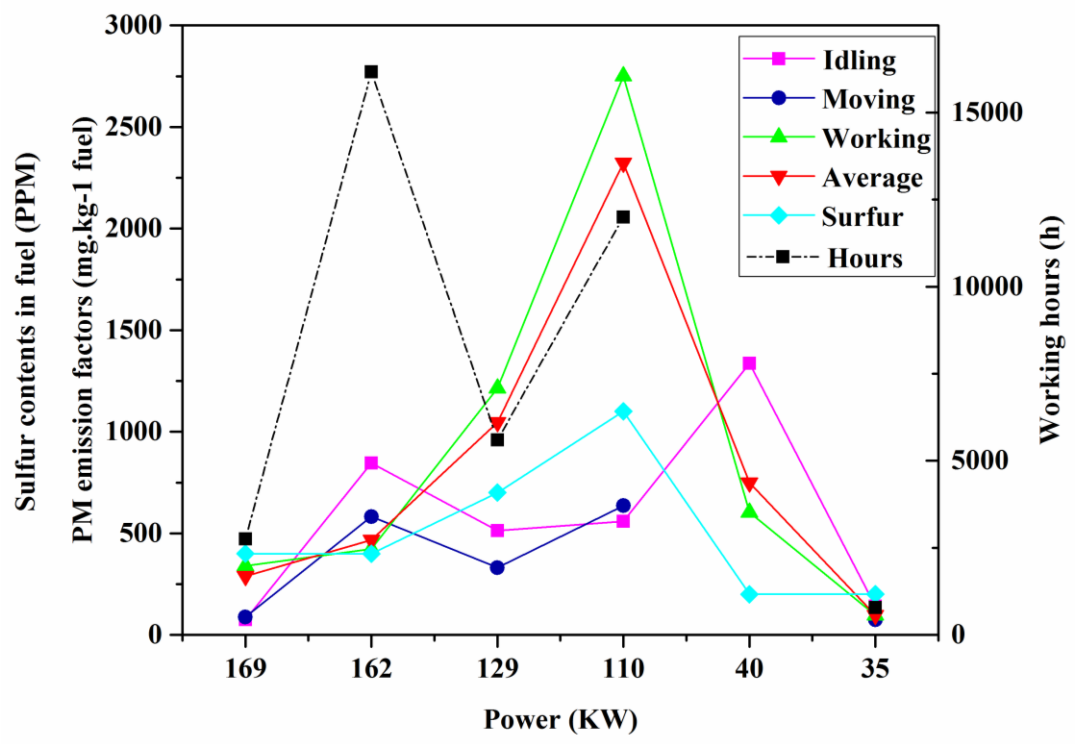

Figure S5 PM emission factors for different power excavators

Table S1 Pollutions emission of generation standards for trucks (g łkwh^{-1})

Emission Standards	Standards	Implementation Data	Test Methods	CO	NMHC	NOx	PM
China I	GB 17691-2001	2001/9/1	/	4.5	1.1	8	0.49
China II	GB 17691-2001	2004/9/1	/	4	1.1	7	0.15
China III	GB 17691-2005	2007/1/1	ESC/ELR	2.1	0.66	5	0.1
			ETC	5.45	0.78	1.6	5
China IV	GB 17691-2005	2010/1/1	ESC/ELR	1.5	0.46	3.5	0.02
			ETC	4	0.55	1.1	3.5
China V	GB 17691-2005	2012/1/1	ESC/ELR	1.5	0.46	2	0.02
			ETC	4	0.55	1.1	2

Table S2 Pollutions emission of generation standards for excavators (g ⋅kwh^{-1})

Emission Standards	Standards	Implementation Data	Rated Power (kw)	CO	HC	NOx	PM
Stage 1	GB 20891-2007	2007/10/1	130≤Pmax≤560	5	1.3	9.2	0.54
			75≤Pmax<130	5	1.3	9.2	0.7
			37≤Pmax<75	6.5	1.3	9.2	0.85
			18≤Pmax<37	8.4	2.2	10.8	1
			8≤Pmax<18	8.4	/	/	/
			0<Pmax<8	12.3	/	/	/
Stage 2		2009/10/1	130≤Pmax≤560	3.5	1	6	0.2
			75≤Pmax<130	5	1	6	0.3
			37≤Pmax<75	5	1.3	7	0.4
			18≤Pmax<37	5.5	1.5	8	0.8
			8≤Pmax<18	6.6	/	/	0.8
			0<Pmax<8	8	/	/	1

Table S3 Mass concentrations of pollutants emitted from E4 in three idling repeat tests

	O_2[a] (%)	CO_2[a] (%)	CO[a] (ppm)	NOx[a] (ppm)	PM (mg ⋅m^{-3})	OC (mg ⋅m^{-3})	EC (mg ⋅m^{-3})
1	16.2	3.4	309	453	11.9	4.3	1.9
2	16.3	3.4	257	457	14.6	6.1	2.9
3	16.3	3.4	262	445	14.4	6.8	2.5
SD	0.08	0.01	28.6	5.68	1.55	1.26	0.53

a: the datum were presented on other unpublished research

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Table S4 PM mass concentrations emitted from trucks in some repeat tests (mg m^{-3})

Trucks	Roads	1	2	3	SD
Light duty-China III	non-highway 1	15.0	16.2	/	0.87
	highway 1	19.8	30.6	/	7.67
Heavy duty-China II	non-highway 2	21.3	16.1	/	3.68
	non-highway 3	7.87	6.11	6.69	0.89
Medium duty-China III	non-highway 4	11.0	10.3	/	0.49
	highway 2	8.79	17.1	/	5.85
Heavy duty-China III	non-highway 4	5.29	9.56	6.99	2.15
	highway 2	10.6	7.42	/	2.24

Table S5 PM Fueled-based emission factors for excavators (mg kg^{-1} fuel)

serial number of excavators	idling	moving	working	average
E1	75.3	88.7	340	289
E2	845	582	422	468
E3	513	331	1,214	1,047
E4	559	636	2,750	2,323
E5	1,336	/	603	749
E6	141	75.0	97.8	96.5

Table S6 Chemical constituents of PM emitted from individual excavator and truck (%)

	E1	E2	E3	E4	E5	E6	T1	T2	T3	T4	T5
EC	18.1	16.9	21.2	19.9	40.6	83.0	39.8	1.80	43.7	6.83	42.5
OC	44.4	45.2	63.4	53.7	20.9	7.5	2.65	16.3	0.139	28.0	2.36
NH_4^+	0.004	0.029	0.061	0.083	0.042	0.045	0.015	0.979	0.080	0.000	0.000
Cl^-	0.357	0.004	0.010	0.003	0.007	0.209	0.070	0.411	0.053	0.007	0.009
NO_3^-	0.106	0.285	0.245	0.112	0.357	0.562	0.908	0.982	1.628	1.409	0.452
SO_4^{2-}	0.064	0.016	0.134	0.520	0.032	0.395	0.423	11.4	1.41	0.191	2.89
Na	0.076	0.066	0.010	0.007	0.060	1.252	0.016	0.103	0.038	0.052	0.029
Mg	0.089	0.056	0.011	0.013	0.007	0.458	0.000	0.085	0.047	0.171	0.091
K	0.080	0.055	0.010	0.058	0.024	0.955	0.011	0.043	0.019	0.042	0.028
Ca	0.193	0.125	0.028	0.035	0.040	1.024	0.016	0.305	0.141	0.458	0.138
Ti	0.006	0.003	0.001	0.002	nd	0.037	0.000	0.022	0.012	0.014	0.007
V	0.0003	0.0002	0.0001	0.0003	0.00004	0.004	0.000	0.000	0.000	0.000	0.000
Cr	0.024	0.050	0.008	0.005	0.003	0.120	0.003	0.046	0.012	0.021	0.110
Mn	0.010	0.006	0.001	0.004	0.0003	0.057	0.000	0.010	0.002	0.011	0.022
Fe	0.837	0.455	0.084	0.183	0.058	3.275	0.031	0.282	0.078	0.330	0.660
Co	0.0002	0.0001	0.00002	0.0001	0.002	0.001	0.001	0.010	0.007	0.005	0.004
Ni	0.025	0.008	0.002	0.003	0.003	0.051	0.001	0.013	0.004	0.003	0.011
Cu	0.036	0.029	0.005	0.030	0.002	0.151	0.002	0.283	0.028	0.013	0.210
Zn	0.032	0.015	0.002	0.036	0.007	0.070	0.009	0.241	0.078	0.031	0.196
Pb	0.006	0.007	0.001	0.001	0.002	0.049	0.001	0.028	0.003	0.006	0.013
C12	nd		nd	0.010	nd		nd	0.099	nd	nd	nd
C13	nd		0.001	0.009	nd		nd	nd	nd	nd	nd
C14	nd		0.001	0.019	nd		nd	0.001	nd	nd	nd

C15	nd	0.001	0.121	0.001	nd	nd	0.067	nd	nd
C16	nd	0.001	0.720	nd	nd	nd	0.311	nd	nd
C17	0.004	0.048	0.115	0.009	0.004	0.009	0.667	0.020	0.018
C18	0.035	0.314	1.794	0.224	0.037	0.060	0.722	0.133	0.124
C19	0.321	0.759	1.597	0.750	0.161	0.150	0.737	0.220	0.273
C20	0.648	1.006	1.880	0.985	0.207	0.190	0.651	0.236	0.272
C21	1.09	1.108	0.011	0.929	0.205	0.183	0.616	0.204	0.240
C22	0.485	0.524	1.036	0.324	0.085	0.079	0.385	0.079	0.088
C23	0.419	0.423	0.750	0.223	0.061	0.056	0.266	0.059	0.053
C24	0.296	0.288	0.546	0.124	0.039	0.034	0.166	0.039	0.027
C25	0.183	0.186	0.247	0.062	0.022	0.016	0.090	0.022	0.012
C26	0.069	0.082	0.009	0.029	0.010	0.007	0.050	0.009	0.004
C27	0.025	0.039	0.066	0.018	0.005	0.004	0.026	0.005	0.003
C28	0.011	0.016	0.058	0.008	0.002	0.002	0.012	0.002	0.002
C29	0.007	0.007	0.034	0.004	0.001	0.002	0.007	0.001	0.001
C30	0.003	0.005	0.019	0.002	nd	0.001	0.003	0.001	0.0004
C31	0.004	0.005	0.032	0.001	0.005	0.001	0.002	nd	0.00005
C32	0.003	0.002	0.033	0.001	0.003	nd	0.001	0.0004	nd
C33	0.003	0.002	0.034	0.001	nd	nd	0.00003	nd	nd
C34	0.002	0.003	0.033	0.001	0.002	nd	nd	0.0002	nd
C35	0.002	0.003	0.047	0.001	nd	nd	nd	0.0002	nd
C36	0.001	0.003	0.059	0.0004	nd	nd	nd	nd	nd
C37	nd	0.002	0.071	nd	nd	nd	nd	nd	nd
C38	0.002	0.005	0.094	0.001	nd	nd	nd	nd	nd
C39	0.002	0.006	0.116	0.001	nd	nd	nd	nd	nd
C40	0.001	0.005	0.005	0.001	nd	nd	nd	nd	nd

Nap	0.012	0.010	0.006	0.004	nd	0.001	nd	0.004	nd
Acy	0.006	0.007	0.006	0.002	nd	nd	nd	0.001	nd
Ace	0.002	0.002	0.001	0.0004	nd	nd	nd	0.0002	nd
Flu	nd	0.0001	0.006	0.00001	nd	nd	0.0004	nd	nd
Phe	0.001	0.003	0.017	0.0004	0.0002	0.001	0.103	0.001	0.001
Ant	0.0001	0.001	0.002	0.00003	nd	nd	0.005	nd	0.001
Fluo	0.004	0.069	0.027	0.004	0.001	0.009	0.032	0.004	0.003
Pyr	0.013	0.087	0.004	0.006	0.002	0.026	0.382	0.022	0.008
BaA	0.002	0.019	0.005	0.001	0.0001	0.002	0.001	0.001	0.0002
Chry	0.005	0.025	0.001	0.001	0.0001	0.005	0.002	0.001	0.001
BbF	0.001	0.007	0.001	0.001	nd	0.001	0.001	0.0004	nd
BkF	0.0001	0.002	0.001	0.0001	nd	0.0002	0.0002	0.0001	nd
BaP	nd	0.001	0.0004	0.00002	nd	nd	0.0001	nd	nd
IcdP	0.001	0.001	0.001	0.002	nd	nd	0.0001	nd	nd
DahA	nd	0.0003	0.001	nd	0.0001	0.002	0.002	0.0004	0.0001
BghiP	0.004	0.003	nd	0.005	0.001	0.009	0.009	0.002	0.001
ABB	0.0003	0.001	0.004	0.0001	0.00002	0.001	0.001	0.001	0.0001
AAA	0.0003	0.001	0.007	0.0001	0.00005	0.001	0.001	0.0005	0.0002
Tm	0.001	0.001	0.003	0.0001	0.001	0.001	0.002	0.001	0.0003
30AB	0.002	0.005	0.036	0.0004	0.001	0.007	0.010	0.004	0.002
29AB	0.002	0.004	0.036	0.0003	0.001	0.007	0.007	0.005	0.002

nd not detected;