atmosphere

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Supplementary materials

PM_{10} Resuspension of Road Dust in Different Types of Parking Lots: Emissions, Chemical Characterisation and Ecotoxicity

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Figure S1. Map of Aveiro and indication of sampling sites. Source: Google Earth image.

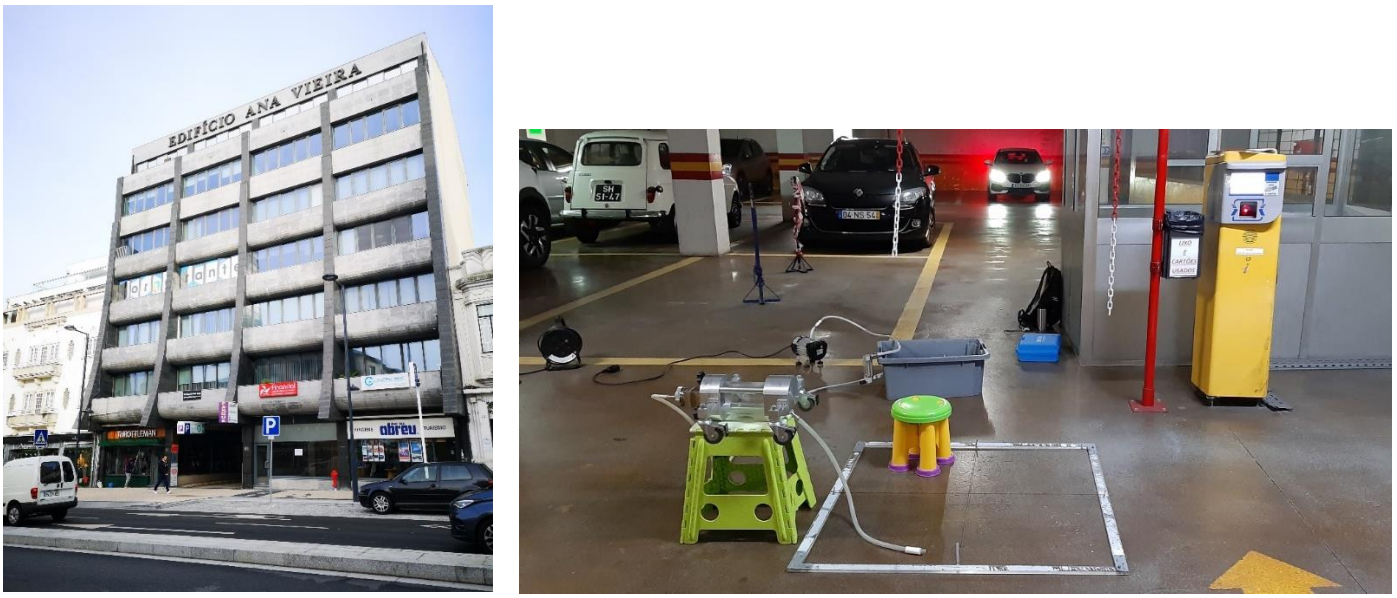

Figure S2. Multi-storey indoor parking. Source: our own pictures.

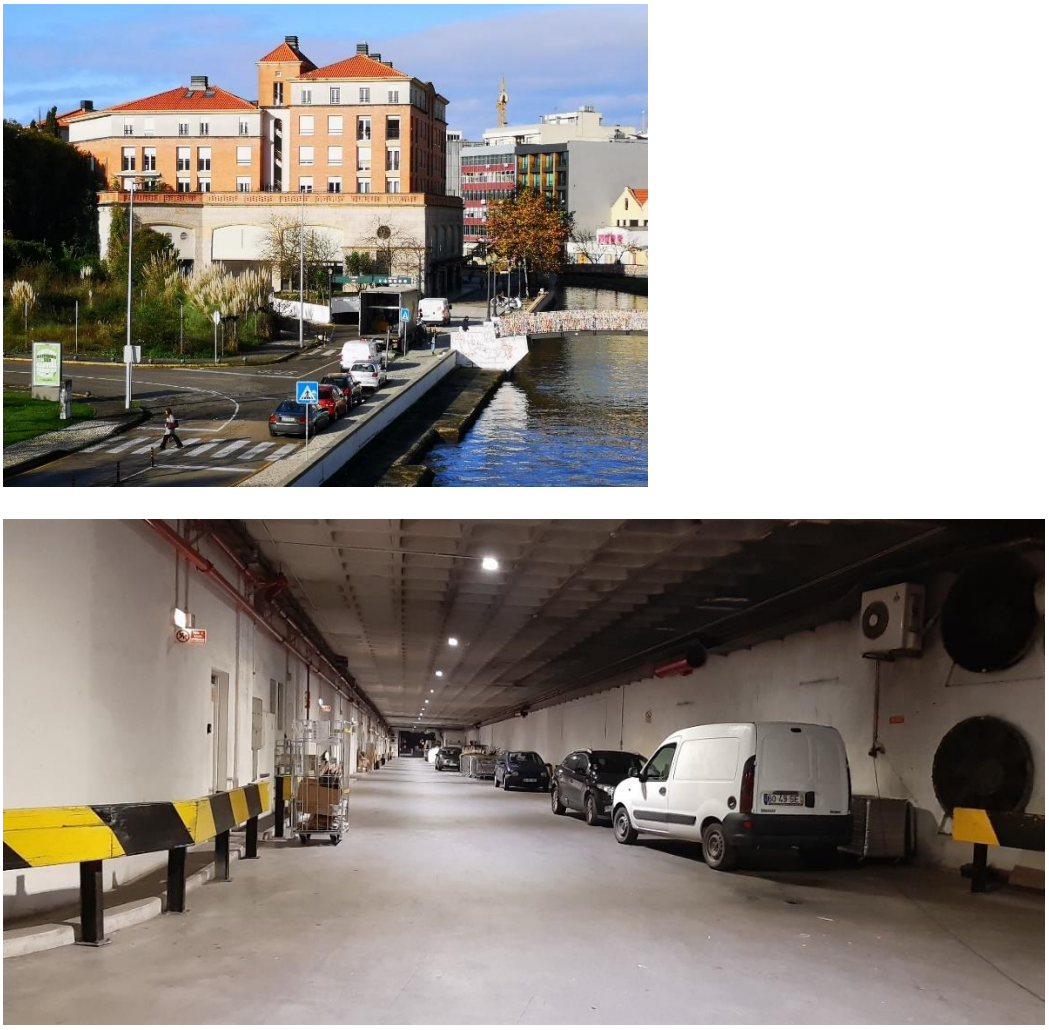

Figure S3. Shopping mall (FORUM Aveiro) and the entrance for loading trucks, vans and other vehicles. Source: our own pictures.

Table S1. Dust loadings and emission factors.

Sampling location and characteristics			DL_{10} (mg m^{-2})		EF (g veh^{-1} km^{-1})	
Aveiro	**Outdoor parking of university campus, Campus UA (P1)**	Area by the entrance, lane that gives access to parking lots	8.9	18.5 ± 9.8	269.3	475.8 ± 206.8
		Lane of parking lots	17.9		475.3	
		Exit area, degraded pavement with loose sand	28.5		682.9	
Aveiro	**Indoor multi-storey parking, Parque Ana Vieira (P2)**	Beginning of the ramp from level -1 to ground floor, smooth pavement with some big cracks	25.7	23.7 ± 8.1	634.3	589 ± 166.1
		20 cm upper in the same ramp, left side of wheel track	34		799.1	
		right side of wheel track	23.9		597.8	
		close to the end of the rump, upper side, right wheel track, rougher pavement	16		431.9	
		ground floor lane with smooth pavement, right wheel track	29.8		710.6	
		by the exit, where the ticket is showed to check out	12.7		360.5	
		by the exit, after cleaning	1.8	1.8	75.2	75.2
Aveiro	**Shopping mall loading site, FORUM Aveiro (P3)**	Area allocated to loading and unloading of vans and trucks, small roundabout. In addition: waste sorting area, deposit area for textile products.	14	20.9 ± 9.7	389.8	533.5 ± 203.3
			27.7		677.2	

Table S2. Element oxide mass concentration for major and minor elements in the sampling sites.

Element oxides	**P1 (Campus UA)**					**P2AVG (Indoor multistorey)**					**P3 (Underground)**				
Major element oxides ($mg\ g^{-1}\ PM_{10}$)	Avg	±	stdev	Min	Max	Avg	±	stdev	Min	Max	Avg	±	stdev	Min	Max
Si	43.6	±	15.8	27.1	58.7	99.4	±	17.1	81.6	120.3	78.6	±	23.7	61.9	95.3
Al	14.5	±	5.3	9.0	19.6	33.1	±	5.7	27.2	40.1	26.2	±	7.9	20.6	31.8
Ca	190.7	±	34.6	159.0	227.6	104.7	±	42.9	58.7	154.6	84.0	±	17.6	71.6	96.5
Fe	12.0	±	6.5	5.5	18.4	24.6	±	11.2	9.1	36.5	18.9	±	3.8	16.2	21.6
K	1.7	±	0.8	0.7	2.4	5.8	±	1.6	3.6	7.6	4.4	±	1.9	3.0	5.7
Mg	2.4	±	0.1	2.3	2.4	5.5	±	1.1	4.5	7.1	3.7	±	1.1	2.9	4.4
Mn	0.2	±	0.1	0.1	0.2	0.3	±	0.2	0.1	0.5	0.2	±	0.1	0.2	0.3
P	0.7	±	0.1	0.7	0.8	1.8	±	1.1	0.7	3.6	2.2	±	0.6	1.8	2.6
S	2.6	±	0.5	2.2	3.2	8.3	±	2.6	4.8	11.9	10.8	±	3.1	8.6	13.0
Ti	0.6	±	0.1	0.5	0.7	2.1	±	0.5	1.2	2.6	1.8	±	0.4	1.5	2.1
Minor element oxides ($\mu g\ g^{-1}\ PM_{10}$)	Avg	±	stdev	Min	Max	Avg	±	stdev	Min	Max	Avg	±	stdev	Min	Max
Li	21.0	±	6.9	13.1	25.1	77.8	±	22.8	43.7	102.3	53.5	±	11.0	45.6	61.3
Be	0.6	±	0.7	0.2	1.4	3.7	±	1.2	2.0	4.8	2.1	±	1.6	0.9	3.2
Sc	2.2	±	0.7	1.5	2.9	3.9	±	1.2	2.7	5.5	2.9	±	0.7	2.4	3.4
V	31.0	±	2.4	28.3	32.8	64.6	±	21.7	36.2	88.9	37.6	±	9.1	31.1	44.1
Cr	147.2	±	102.0	56.9	257.9	241.8	±	136.8	72.8	381.7	129.8	±	15.1	119.1	140.5
Co	2.4	±	0.5	1.8	2.8	6.1	±	2.5	2.7	8.9	5.6	±	1.3	4.7	6.5
Ni	27.7	±	8.4	22.8	37.4	58.6	±	41.2	16.6	103.1	30.6	±	5.4	26.8	34.4
Cu	251.5	±	165.9	99.6	428.5	604.1	±	337.4	165.9	1048.6	327.3	±	22.0	311.7	342.8

Zn	835.3	±	806.0	332.4	1764.9	1974.7	±	754.4	1032.3	3070.2	2232.6	±	478.8	1894.0	2571.1
Ga	3.8	±	1.0	2.8	4.8	9.7	±	2.4	6.6	12.0	7.0	±	2.0	5.6	8.4
Ge	0.7	±	0.2	0.5	0.8	1.6	±	0.2	1.3	1.9	1.1	±	0.4	0.9	1.3
As	1.3	±	1.1	0.2	2.4	6.7	±	3.4	3.1	10.6	4.6	±	2.5	2.8	6.4
Se	0.2	±	0.2	0.1	0.4	0.9	±	0.2	0.7	1.0	0.4	±	0.2	0.2	0.5
Rb	22.7	±	7.8	14.1	29.4	70.0	±	17.0	45.7	87.1	45.1	±	12.8	36.1	54.1
Sr	99.9	±	7.9	94.0	108.8	200.2	±	72.4	132.7	290.9	108.8	±	27.6	89.3	128.3
Y	5.7	±	0.5	5.2	6.3	6.7	±	2.3	4.0	9.7	7.3	±	2.5	5.6	9.1
Zr	63.5	±	43.1	22.3	108.2	112.6	±	51.2	61.6	184.6	46.9	±	2.5	45.1	48.6
Nb	1.1	±	0.6	0.4	1.5	4.8	±	3.1	1.2	8.3	3.3	±	1.5	2.2	4.4
Mo	8.8	±	7.4	2.2	16.7	24.6	±	13.8	7.6	42.3	7.9	±	1.5	6.9	9.0
Cd	0.3	±	0.0	0.2	0.3	0.4	±	0.2	0.2	0.6	0.5	±	0.2	0.4	0.6
Sn	33.4	±	27.9	13.7	65.4	102.9	±	67.3	43.3	206.4	12.7	±	11.0	4.9	20.5
Sb	5.8	±	4.4	1.7	10.4	22.8	±	11.4	8.8	32.2	13.4	±	1.3	12.4	14.4
Cs	1.5	±	0.5	1.0	1.9	5.4	±	1.5	3.6	7.6	3.4	±	1.0	2.6	4.1
Ba	733.6	±	550.0	235.5	1323.9	1749.4	±	514.4	1059.1	2348.1	1569.8	±	356.8	1317.5	1822.0
La	6.8	±	0.5	6.4	7.3	12.7	±	2.2	10.4	15.6	9.3	±	2.9	7.2	11.4
Ce	11.5	±	2.2	9.2	13.5	25.1	±	5.1	20.4	32.9	17.3	±	5.5	13.4	21.2
Pr	1.3	±	0.3	1.0	1.6	2.5	±	0.4	2.0	3.1	1.8	±	0.6	1.4	2.2
Nd	5.3	±	1.0	4.2	6.3	10.4	±	1.5	8.6	12.3	8.0	±	2.5	6.2	9.7
Sm	1.0	±	0.2	0.8	1.2	1.8	±	0.3	1.5	2.1	1.3	±	0.5	1.0	1.7
Eu	0.2	±	0.0	0.1	0.2	0.4	±	0.1	0.2	0.5	0.4	±	0.1	0.3	0.5
Gd	1.0	±	0.2	0.8	1.2	1.9	±	0.4	1.6	2.4	1.4	±	0.4	1.1	1.7
Tb	0.1	±	0.0	0.1	0.1	0.2	±	0.1	0.1	0.3	0.2	±	0.1	0.2	0.3
Dy	0.7	±	0.1	0.6	0.8	1.1	±	0.3	0.9	1.5	0.9	±	0.3	0.7	1.1
Ho	0.1	±	0.0	0.1	0.2	0.2	±	0.1	0.1	0.3	0.2	±	0.1	0.1	0.2
Er	0.4	±	0.1	0.3	0.5	0.6	±	0.1	0.4	0.8	0.5	±	0.2	0.3	0.6

Tm	0.0	±	0.0	0.0	0.1	0.1	±	0.0	0.1	0.1	0.1	±	0.0	0.0	0.1
Yb	0.3	±	0.1	0.3	0.4	0.5	±	0.2	0.4	0.7	0.4	±	0.1	0.3	0.5
Lu	0.0	±	0.0	0.0	0.1	0.1	±	0.0	0.1	0.1	0.1	±	0.0	0.0	0.1
Hf	1.4	±	1.0	0.4	2.4	2.5	±	1.0	1.7	3.9	1.1	±	0.0	1.1	1.1
Ta	nd		nd	0.0	0.0	0.4	±	0.3	0.1	0.6	0.1	±	0.0	0.1	0.1
W	nd		nd	0.0	0.0	5.5	±	0.0	5.5	5.5	nd		nd	0.0	0.0
Tl	nd		nd	0.0	0.0	0.3	±	0.2	0.0	0.5	0.2	±	0.0	0.2	0.2
Pb	22.7	±	7.8	14.3	29.7	129.7	±	37.1	75.3	174.4	89.4	±	21.1	74.5	104.3
Bi	2.7	±	2.5	0.6	5.5	45.0	±	14.5	31.0	67.6	3.7	±	0.3	3.5	3.9
Th	2.2	±	0.8	1.3	2.9	3.6	±	0.8	2.4	4.4	2.7	±	0.8	2.2	3.3
U	1.6	±	0.6	1.2	2.3	2.6	±	0.9	1.6	3.8	2.0	±	0.6	1.5	2.4

nd – not determined

Table S3. The geoaccumulation index (I_{geo}) and the values obtained in the three parking areas.

Class 0	<0	Uncontaminated
Class 1	0-1	Uncontaminated to moderately contaminated
Class 2	1-2	Moderately contaminated
Class 3	2-3	Moderately to heavily contaminated
Class 4	3-4	Heavily contaminated
Class 5	4-5	Heavily to Extremely contaminated
Class 6	>5	Extremely contaminated

Geoaccumulation index (I_{geo})			
Major elements	P1	P2$_{AVG}$	P3
Al	-3.0	-1.8	-2.1
Ca	2.1	1.2	0.9
Fe	-2.0	-0.9	-1.3
K	-4.7	-2.9	-3.3
Mg	-3.1	-1.9	-2.5
Mn	-2.4	-1.3	-1.8
P	-0.5	0.8	1.1
S	0.9	2.5	2.9
Ti	-3.0	-1.1	-1.3
Minor elements	P1	P2$_{AVG}$	P3
Li	-0.6	1.2	0.7
Be	-3.0	-0.3	-1.2
Sc	-2.3	-1.4	-1.9
V	-1.4	-0.3	-1.1
Cr	1.5	2.2	1.3
Co	-2.9	-1.5	-1.6
Ni	0.0	1.1	0.1
Cu	3.6	4.8	3.9
Zn	3.4	4.7	4.8
Ga	-2.5	-1.1	-1.6
Ge	-1.6	-0.3	-0.9
As	-1.2	1.2	0.6
Se	0.9	2.8	1.6
Rb	-2.9	-1.2	-1.9
Sr	-2.2	-1.2	-2.1
Y	-2.4	-2.2	-2.1
Zr	-2.5	-1.7	-2.9
Nb	-5.1	-3.0	-3.6
Mo	2.1	3.6	1.9
Cd	0.8	1.5	1.6
Sn	3.2	4.8	1.8

Sb	3.6	5.6	4.8
Cs	-2.5	-0.7	-1.4
Ba	-0.4	0.8	0.6
La	-2.8	-1.9	-2.4
Ce	-3.1	-2.0	-2.5
Pr	-2.8	-1.9	-2.4
Nd	-2.9	-2.0	-2.3
Sm	-2.8	-2.0	-2.4
Eu	-3.4	-2.5	-2.2
Gd	-2.0	-1.2	-1.6
Tb	-2.7	-1.9	-1.7
Dy	-2.7	-2.0	-2.3
Ho	-2.9	-2.3	-2.6
Er	-3.0	-2.4	-2.8
Tm	-3.4	-2.5	-3.1
Yb	-2.7	-2.1	-2.4
Lu	-3.3	-2.4	-3.0
Hf	-2.6	-1.8	-3.0
Ta	nd	-2.7	-5.3
W	nd	1.4	nd
Tl	nd	-2.1	-2.6
Pb	-0.2	2.3	1.8
Bi	3.9	7.9	4.3
Th	-2.8	-2.1	-2.5
U	-1.2	-0.5	-0.9

nd =not determined.

Table S4. PAHs content.

PAH mass concentration (μg g^{-1} PM_{10})	Avg P1	$P2_{AVG}$	$P2_{BC}$	$P2_{AC}$	Avg P3
Naphthalene	6.94	2.52	0.51	14.60	4.44
2-Methylnaphthalene	<dl	0.02	0.02	<dl	<dl
1-Methylnaphthalene	<dl	0.02	0.02	<dl	0.04
Acenaphthylene	<dl	0.06	0.07	<dl	0.09
Acenaphthene	<dl	0.09	0.10	<dl	0.09
Fluorene	0.96	0.80	0.88	0.36	0.40
Phenanthrene	7.13	3.61	2.27	11.68	10.32
Anthracene	1.35	0.52	0.24	2.19	0.63
Fluoranthene	1.35	0.78	0.84	0.36	1.35
Pyrene	0.58	1.50	1.56	1.09	1.71
Benzanthracene	0.00	0.49	0.26	1.82	0.45
Chrysene	0.58	0.38	0.32	0.73	0.58
Benzo(b)fluoranthene	0.96	0.53	0.38	1.46	0.54
Benzo(k)fluoranthene	0.58	0.29	0.21	0.73	0.31
Benzo(e)pyrene	0.77	0.33	0.26	0.73	0.45
Benzo(a)pyrene	0.77	0.22	0.26	<dl	0.36
Dibenzo(a,h)anthracene	0.58	0.21	0.19	0.36	0.36
Indeno(1,2,3-cd)pyrene	0.19	0.05	0.06	<dl	0.13
Benzo(g,h,i)perylene	0.58	0.60	0.58	0.73	0.94
Total naphthalene	6.94	2.56	0.55	14.60	4.49
Total PAHs without naphthalene	17.35	9.89	7.83	22.26	0.76
Total PAHs	24.28	12.45	8.38	36.86	23.20

dl – detection limit

Table S5. Results for the bioluminescence bioassay with *Aliivibrio fisheri* bacteria, including EC_{50} (% and mass concentration) and toxic units (TU).

Sampling location		Sample	Area (cm^2)	PM in extracted area (µg)	Extraction volume (ml)	PM in liquid extract (µg ml^{-1})	EC_{50} (%)	EC_{50} (µg ml^{-1})	EC_{20} (%)	EC_{20} (µg ml^{-1})	TU	Toxicity
Parking areas	Campus UA (P1)	AEQ_26	1.57	476	2	238.07	65.78	157	13.40	32	1.52	TOXIC
		AEQ_27	5.86	4088	4	1022.04	33.62	344	13.59	139	2.97	TOXIC
		AEQ_29	5.86	1931	4	482.76	94.81	458	15.42	74	1.05	TOXIC
	Parque Ana Vieira (P2)	AEQ_18	5.56	9355	4	2338.76	19.57	458	4.17	98	5.11	TOXIC
		AEQ_19	7.52	20374	4	5093.48	17.51	892	2.11	107	5.71	TOXIC
		AEQ_20	5.95	6720	4	1680.04	26.36	443	4.37	73	3.79	TOXIC
		AEQ_21	5.56	4101	4	1025.23	48.00	492	8.41	86	2.08	TOXIC
		AEQ_22	1.57	2543	2	1271.70	32.42	412	5.50	70	3.08	TOXIC
		AEQ_30	1.57	264	2	132.23	28.11	37	12.95	17	3.56	TOXIC
	FORUM UA (P3)	AEQ_31	5.23	3006	4	751.47	19.65	148	3.59	27	5.09	TOXIC
		AEQ_32	5.95	6342	4	1585.60	24.25	385	5.10	81	4.12	TOXIC
		AEQ_33	5.56	6300	4	1574.89	18.39	290	4.71	74	5.44	TOXIC

NON-TOXIC	TU < 1
TOXIC	1 < TU < 10
VERY TOXIC	10 < TU < 100
EXTREMELY TOXIC	TU > 100