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Article

Adsorption of Metals to Particles in Urban Stormwater Runoff—Does Size Really Matter?

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Supplementary Materials

Table S1. average recovery rates of certified reference material (CRM BCR–723 "Road Dust" and NIST 1640a)

Element	Recovery Rate (%)	Standard Deviation (%)
Cr	100	2,9
Cu	99	3,4
Zn	111	3,6
Cd	104	5,0
Pb	92	1,5

Table S2. characteristics of sampled rain events.

Sample	Date of Rain Event	Total Rainfall Volume (mm)	Rain Duration (h)	Rain Intensity (mm h^{-1})
2018_0314	12 March 2018	3.00	18.5	0.16
2018_0323	18 March 2018	1.00	1.33	0.75
2018_0404	28 March 2018	1.70	20.3	0.08
2018_0406	04 April 2018	1.80	11.8	0.27
2018_0412	10 April 2018	1.40	1.00	1.90
2018_0720	15 July 2018	1.90	5.33	0.17
2018_0828	23 August 2018	0.90	5.33	2.06
2018_0914	06 September 2018	11.0	9.00	0.27
2018_0928	21 September 2018	2.40	9.17	0.16
2018_1030	27 October 2018	14.4	34.3	0.42
2018_1107	01 November 2018	2.30	1.83	1.25
2018_1114	10 November 2018	6.60	11.3	0.58
2018_1127	23 November 2018	2.20	3.67	0.60
2018_1205	02 December 2018	11.2	22.3	0.50
2018_1213	07, 09, 10 December 2018	4.50	13.67	0.33
2018_1220	16 December 2018	1.40	3.17	0.44
2019_0108	05, 06 January 2019	4.10	26.7	0.15

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Table S3. Sample specific event mean concentrations, pH, and temperature.

Sample	pH	T(C°)	TSS (mg l^{-1})					
			<63 μm	63–125 μm	125–250 μm	250–2000 μm	Total	Dissolved
2018_0314	7.6	9.9	95.5	4.70	3.56	5.65	109	–
2018_0323	7.4	8.1	18.9	0.85	0.73	0.90	21.3	–
2018_0404	7.1	12.7	27.4	1.67	1.81	2.23	33.1	–
2018_0406	6.9	9.4	33.8	2.66	2.33	2.75	41.6	–
2018_0412	7.1	13.4	191	17.2	21.8	6.70	237	–
2018_0720	6.7	21.4	52.1	23.6	87.6	60.5	224	–
2018_0828	6.7	18.5	67.3	14.8	6.93	9.33	98.4	–
2018_0914	6.8	19.1	15.9	2.46	1.29	1.19	20.8	–
2018_0928	6.8	16.2	48.7	9.03	4.35	4.08	66.1	–
2018_1030	7.1	9.9	12.7	1.51	0.59	0.76	15.5	–
2018_1107	7.0	9.5	20.8	1.19	0.80	1.43	24.3	–
2018_1114	7.0	10.2	22.1	2.13	1.14	2.34	27.7	–
2018_1127	6.9	7.8	22.6	3.52	2.57	4.62	33.4	–
2018_1205	7.2	10.2	51.5	3.87	2.05	2.41	59.8	–
2018_1213	6.9	5.8	33.9	4.38	2.11	2.47	42.8	–
2018_1220	6.9	8.5	7.52	0.54	0.50	0.39	8.95	–
2019_0108	7.2	7.8	12.1	0.67	0.57	0.81	14.1	–
Sample	pH	T(C°)	Cr (μg l^{-1})					
			<63 μm	63–125 μm	125–250 μm	250–2000 μm	Total	Dissolved
2018_0314	7.6	9.9	22.5	0.77	0.60	0.81	25.3	0.60
2018_0323	7.4	8.1	5.08	0.23	0.19	0.12	8.82	3.19
2018_0404	7.1	12.7	6.52	0.30	0.37	0.30	8.21	0.72
2018_0406	6.9	9.4	6.84	0.39	0.39	0.19	8.94	1.13
2018_0412	7.1	13.4	27.2	7.56	5.12	1.10	41.9	0.87
2018_0720	6.7	21.4	16.9	6.20	5.57	9.05	38.9	1.26
2018_0828	6.7	18.5	22.4	4.25	1.59	1.12	29.5	0.13
2018_0914	6.8	19.1	5.34	0.56	0.28	0.26	6.71	0.27
2018_0928	6.8	16.2	8.83	1.09	0.61	0.38	11.2	0.28
2018_1030	7.1	9.9	4.35	0.51	0.13	0.16	5.42	0.28
2018_1107	7.0	9.5	5.99	0.34	0.31	0.64	7.55	0.27
2018_1114	7.0	10.2	3.65	0.54	0.28	0.33	4.98	0.19
2018_1127	6.9	7.8	2.35	0.97	0.20	0.17	3.92	0.23
2018_1205	7.2	10.2	12.5	0.77	0.60	0.20	14.2	0.09
2018_1213	6.9	5.8	7.55	0.69	0.28	0.38	9.15	0.25
2018_1220	6.9	8.5	1.19	<0.1	<0.1	<0.1	1.60	0.27
2019_0108	7.2	7.8	1.71	0.13	<0.1	<0.1	2.28	0.35
Sample	pH	T(C°)	Cu (μg l^{-1})					
			<63 μm	63–125 μm	125–250 μm	250–2000 μm	Total	Dissolved
2018_0314	7.6	9.9	28.6	2.07	1.56	3.29	45.8	10.2
2018_0323	7.4	8.1	18.5	0.50	0.31	0.36	24.7	5.03
2018_0404	7.1	12.7	20.6	1.08	1.03	0.70	37.2	13.8
2018_0406	6.9	9.4	23.2	1.48	1.19	0.79	38.7	12.0
2018_0412	7.1	13.4	65.4	16.1	13.0	3.22	108	10.3
2018_0720	6.7	21.4	38.1	19.2	11.0	18.2	102	15.1
2018_0828	6.7	18.5	10.7	2.09	0.81	2.19	22.3	6.49
2018_0914	6.8	19.1	11.3	0.93	0.16	0.77	28.9	15.8
2018_0928	6.8	16.2	7.39	4.46	0.85	2.01	26.6	11.9

2018_1030	7.1	9.9	1.75	1.99	1.15	0.81	19.3	13.6
2018_1107	7.0	9.5	23.3	0.67	0.29	0.81	44.1	19.1
2018_1114	7.0	10.2	3.92	1.17	0.12	1.55	15.3	8.49
2018_1127	6.9	7.8	9.74	4.44	0.65	0.77	26.3	10.7
2018_1205	7.2	10.2	18.6	1.23	0.74	0.46	24.0	3.00
2018_1213	6.9	5.8	13.2	1.33	0.81	0.87	23.0	6.81
2018_1220	6.9	8.5	5.36	0.16	0.25	0.15	17.5	11.6
2019_0108	7.2	7.8	3.91	0.20	<0.1	<0.1	14.3	10.0
					Zn (µg l^{-1})			
Sample	**pH**	**T(C°)**	**<63 µm**	**63–125 µm**	**125–250 µm**	**250–2000 µm**	**Total**	**Dissolved**
2018_0314	7.6	9.9	134	11.9	9.91	19.7	347	171.6
2018_0323	7.4	8.1	78.7	2.88	1.98	2.26	157	71.3
2018_0404	7.1	12.7	112	6.87	7.09	4.95	247	116
2018_0406	6.9	9.4	105	8.14	7.37	4.14	239	115
2018_0412	7.1	13.4	323	71.3	63.7	15.0	735	262
2018_0720	6.7	21.4	265	131	26.9	105	835	306
2018_0828	6.7	18.5	56.6	8.69	4.07	10.4	244	165
2018_0914	6.8	19.1	59.1	1.45	8.00	2.23	276	206
2018_0928	6.8	16.2	28.2	14.3	2.95	24.6	267	197
2018_1030	7.1	9.9	22.4	7.76	4.35	3.95	276	237
2018_1107	7.0	9.5	143	3.27	1.98	2.75	533	382
2018_1114	7.0	10.2	14.7	3.19	2.75	6.66	245	218
2018_1127	6.9	7.8	26.7	15.8	2.24	6.02	449	399
2018_1205	7.2	10.2	94.4	8.07	4.35	3.25	242	132
2018_1213	6.9	5.8	61.1	8.46	5.04	8.74	295	212
2018_1220	6.9	8.5	17.5	1.40	1.24	0.96	314	293
2019_0108	7.2	7.8	38.2	1.73	1.33	1.97	256	213
					Cd (µg l^{-1})			
Sample	**pH**	**T(C°)**	**<63 µm**	**63–125 µm**	**125–250 µm**	**250–2000 µm**	**Total**	**Dissolved**
2018_0314	7.6	9.9	0.10	<0.1	<0.1	<0.1	0.20	<0.1
2018_0323	7.4	8.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
2018_0404	7.1	12.7	<0.1	<0.1	<0.1	< 0.1	0.13	<0.1
2018_0406	6.9	9.4	<0.1	<0.1	<0.1	<0.1	0.11	<0.1
2018_0412	7.1	13.4	0.21	<0.1	<0.1	<0.1	0.50	0.21
2018_0720	6.7	21.4	0.18	<0.1	<0.1	<0.1	0.58	0.20
2018_0828	6.7	18.5	<0.1	<0.1	<0.1	<0.1	0.12	<0.1
2018_0914	6.8	19.1	<0.1	<0.1	<0.1	<0.1	0.15	<0.1
2018_0928	6.8	16.2	<0.1	<0.1	<0.1	<0.1	0.12	<0.1
2018_1030	7.1	9.9	<0.1	<0.1	<0.1	<0.1	0.09	<0.1
2018_1107	7.0	9.5	0.11	<0.1	<0.1	<0.1	0.28	0.16
2018_1114	7.0	10.2	<0.1	<0.1	<0.1	<0.1	0.13	0.10
2018_1127	6.9	7.8	<0.1	<0.1	<0.1	<0.1	0.15	0.10
2018_1205	7.2	10.2	<0.1	<0.1	<0.1	<0.1	0.11	<0.1
2018_1213	6.9	5.8	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2018_1220	6.9	8.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
2019_0108	7.2	7.8	<0.1	<0.1	<0.1	<0.1	0.11	<0.1
					Pb (µg l^{-1})			
Sample	**pH**	**T(C°)**	**<63 µm**	**63–125 µm**	**125–250 µm**	**250–2000 µm**	**Total**	**Dissolved**
2018_0314	7.6	9.9	6.37	0.73	0.65	0.97	8.87	0.15
2018_0323	7.4	8.1	2.65	0.13	<0.1	<0.1	2.97	<0.1
2018_0404	7.1	12.7	4.07	0.27	0.27	0.15	4.82	<0.1

2018_0406	6.9	9.4	4.80	0.40	0.33	0.15	5.73	<0.1
2018_0412	7.1	13.4	18.7	4.45	3.90	0.70	29.0	1.28
2018_0720	6.7	21.4	10.8	6.64	2.68	11.3	31.5	<0.1
2018_0828	6.7	18.5	2.48	0.28	0.18	0.41	3.40	<0.1
2018_0914	6.8	19.1	3.11	0.22	0.55	0.11	4.03	<0.1
2018_0928	6.8	16.2	1.55	1.04	0.17	0.38	3.20	<0.1
2018_1030	7.1	9.9	0.20	0.46	0.24	0.19	1.14	<0.1
2018_1107	7.0	9.5	11.3	0.25	<0.1	0.18	11.8	<0.1
2018_1114	7.0	10.2	0.83	0.23	<0.1	0.33	1.46	<0.1
2018_1127	6.9	7.8	2.29	0.71	0.15	0.17	3.37	<0.1
2018_1205	7.2	10.2	4.48	0.37	0.19	0.11	5.20	<0.1
2018_1213	6.9	5.8	3.94	0.41	0.22	0.28	4.92	<0.1
2018_1220	6.9	8.5	0.65	<0.1	<0.1	<0.1	0.88	0.12
2019_0108	7.2	7.8	0.75	0.23	<0.1	<0.1	1.29	0.25

Table S4. Sample specific treatment efficiencies for TSS, Cr, Cu, Zn, Cd and Pb.

TSS η_M							
	Part. + Diss.	**Diss.**	**Particulate–Bound**				
Sample			**Total**	**<63 µm**	**63–125 µm**	**125–250 µm**	**250–2000 µm**
2018_0314	–	–	0.27	0.18	0.95	0.94	0.94
2018_0323	–	–	0.37	0.31	0.79	0.82	0.82
2018_0404	–	–	0.43	0.32	0.95	0.87	0.98
2018_0406	–	–	0.59	0.50	0.97	0.97	0.99
2018_0412	–	–	0.59	0.11	0.23	0.13	0.43
2018_0720	–	–	1.00	1.00	1.00	1.00	1.00
2018_0828	–	–	0.21	0.15	0.26	0.38	0.47
2018_0914	–	–	0.63	0.56	0.84	0.87	0.88
2018_0928	–	–	0.83	0.81	0.93	0.80	0.96
2018_1030	–	–	0.27	0.19	0.47	0.81	0.79
2018_1107	–	–	0.30	0.20	0.88	0.93	0.92
2018_1114	–	–	0.39	0.27	0.75	0.91	0.95
2018_1127	–	–	0.71	0.59	0.95	0.97	0.96
2018_1205	–	–	0.20	0.13	0.46	0.75	0.82
2018_1213	–	–	0.75	0.70	0.94	0.95	0.93
2018_1220	–	–	0.76	0.74	0.92	0.94	0.78
2019_0108	–	–	0.35	0.74	0.54	0.64	0.75
Chrome η_M							
	Part. + Diss.	**Diss.**	**Particulate–Bound**				
Sample			**Total**	**< 63 µm**	**63–125 µm**	**125–250 µm**	**250–2000 µm**
2018_0314	0.23	0.33	0.22	0.16	0.90	0.94	0.95
2018_0323	0.19	0.23	0.17	0.10	0.82	0.87	0.82
2018_0404	0.36	0.32	0.37	0.29	0.94	0.87	0.98
2018_0406	0.45	0.17	0.49	0.42	0.95	0.96	0.99
2018_0412	0.22	0.09	0.22	0.23	0.15	0.21	0.50
2018_0720	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2018_0828	0.21	0.12	0.21	0.14	0.31	0.49	0.83
2018_0914	0.57	0.41	0.57	0.51	0.83	0.89	0.93
2018_0928	0.73	0.24	0.74	0.72	0.87	0.72	0.95
2018_1030	0.24	0.04	0.25	0.20	0.32	0.85	0.90
2018_1107	0.19	0.13	0.19	0.03	0.85	0.97	0.98

2018_1114	0.55	0.03	0.57	0.50	0.67	0.94	0.96
2018_1127	0.60	0.33	0.61	0.43	0.96	0.93	0.87
2018_1205	0.23	0.03	0.24	0.17	0.60	0.94	0.88
2018_1213	0.69	0.25	0.70	0.66	0.91	0.93	0.94
2018_1220	0.60	0.58	0.60	0.58	0.83	0.91	0.43
2019_0108	0.33	0.52	0.30	0.29	0.46	0.17	0.34

Copper η_M

Sample	Part. + Diss.	Diss.	Particulate–Bound				
			Total	<63 μm	63–125 μm	125–250 μm	250–2000 μm
2018_0314	0.35	0.13	0.41	0.28	0.93	0.96	0.97
2018_0323	0.16	0.27	0.13	0.08	0.85	0.86	0.86
2018_0404	0.34	0.29	0.36	0.28	0.97	0.93	0.98
2018_0406	0.44	0.29	0.50	0.43	0.97	0.98	0.99
2018_0412	0.16	0.11	0.17	0.17	0.14	0.14	0.45
2018_0720	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2018_0828	0.49	0.11	0.64	0.71	0.68	0.68	0.25
2018_0914	0.38	0.31	0.45	0.38	0.81	0.67	0.94
2018_0928	0.49	0.27	0.66	0.41	0.94	0.66	0.98
2018_1030	0.25	0.09	0.61	0.14	0.68	0.97	0.94
2018_1107	0.12	0.11	0.13	0.06	0.86	0.94	0.96
2018_1114	0.17	0.04	0.34	0.16	0.09	0.74	0.97
2018_1127	0.52	0.31	0.65	0.46	0.98	0.96	0.93
2018_1205	0.18	0.02	0.20	0.15	0.38	0.81	0.82
2018_1213	0.60	0.24	0.76	0.72	0.91	0.96	0.94
2018_1220	0.63	0.54	0.80	0.79	0.88	0.96	0.83
2019_0108	0.45	0.45	0.46	0.48	0.32	0.14	0.15

Zinc η_M

Sample	Part. + diss.	Diss.	Particulate–Bound				
			Total	<63 μm	63–125 μm	125–250 μm	250–2000 μm
2018_0314	0.28	0.10	0.46	0.31	0.94	0.97	0.97
2018_0323	0.24	0.31	0.17	0.11	0.85	0.87	0.87
2018_0404	0.33	0.25	0.39	0.29	0.97	0.93	0.98
2018_0406	0.40	0.25	0.54	0.45	0.97	0.98	0.99
2018_0412	0.12	0.05	0.16	0.14	0.17	0.18	0.50
2018_0720	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2018_0828	0.28	0.09	0.69	0.73	0.73	0.81	0.42
2018_0914	0.45	0.44	0.47	0.39	0.30	0.96	0.88
2018_0928	0.45	0.35	0.71	0.42	0.89	0.39	0.99
2018_1030	0.13	0.07	0.47	0.22	0.69	0.96	0.94
2018_1107	0.11	0.12	0.10	0.05	0.87	0.95	0.93
2018_1114	0.09	0.04	0.46	0.23	0.08	0.95	0.97
2018_1127	0.28	0.20	0.94	0.92	0.97	0.93	0.95
2018_1205	0.10	0.02	0.20	0.13	0.39	0.83	0.89
2018_1213	0.43	0.30	0.77	0.71	0.92	0.96	0.96
2018_1220	0.67	0.68	0.60	0.53	0.92	0.95	0.83
2019_0108	0.37	0.41	0.15	0.08	0.55	0.69	0.81

Cadmium η_M

Sample	Part. + Diss.	Diss.	Particulate–Bound				
			Total	<63 μm	63–125 μm	125–250 μm	250–2000 μm
2018_0314	0.24	0.11	0.33	0.20	0.94	0.95	0.96
2018_0323	0.24	0.29	0.18	0.11	0.80	0.84	0.85

2018_0404	0.35	0.29	0.40	0.29	0.97	0.94	0.98
2018_0406	0.45	0.30	0.58	0.49	0.97	0.98	0.99
2018_0412	0.10	0.03	0.16	0.13	0.23	0.18	0.41
2018_0720	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2018_0828	0.39	0.10	0.71	0.78	0.81	0.61	0.25
2018_0914	0.49	0.55	0.42	0.30	0.51	0.98	0.96
2018_0928	0.48	0.44	0.52	0.30	0.87	0.85	0.96
2018_1030	0.29	0.20	0.46	0.18	0.70	0.97	0.96
2018_1107	0.13	0.16	0.10	0.06	0.88	0.96	0.93
2018_1114	0.13	0.03	0.40	0.30	0.24	0.73	0.97
2018_1127	0.34	0.18	0.68	0.34	0.98	0.98	0.93
2018_1205	0.13	0.04	0.20	0.15	0.37	0.63	0.75
2018_1213	0.49	0.39	0.62	0.63	0.01	0.03	0.01
2018_1220	0.60	0.58	0.65	0.59	0.93	0.97	0.81
2019_0108	0.32	0.36	0.16	0.08	0.58	0.76	0.79

Lead η_M

Sample	Part. + Diss.	diss.	Particulate–Bound				
			Total	<63 μm	63–125 μm	125–250 μm	250–2000 μm
2018_0314	0.47	0.32	0.47	0.29	0.95	0.97	0.97
2018_0323	0.18	0.29	0.17	0.11	0.80	0.82	0.85
2018_0404	0.39	0.41	0.39	0.30	0.96	0.94	0.97
2018_0406	0.56	0.30	0.56	0.48	0.97	0.98	0.99
2018_0412	0.14	0.02	0.14	0.13	0.14	0.14	0.56
2018_0720	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2018_0828	0.65	0.06	0.66	0.71	0.75	0.70	0.31
2018_0914	0.60	0.30	0.61	0.53	0.73	0.98	0.89
2018_0928	0.64	0.29	0.65	0.40	0.92	0.63	0.97
2018_1030	0.66	0.05	0.68	0.14	0.67	0.96	0.94
2018_1107	0.36	0.15	0.37	0.34	0.90	0.92	0.95
2018_1114	0.38	0.07	0.39	0.25	0.03	0.46	0.97
2018_1127	0.54	0.38	0.54	0.35	0.97	0.96	0.92
2018_1205	0.21	0.04	0.21	0.15	0.40	0.80	0.83
2018_1213	0.72	0.51	0.72	0.67	0.90	0.97	0.95
2018_1220	0.48	0.52	0.48	0.41	0.86	0.95	0.69
2019_0108	0.43	0.57	0.40	0.27	0.81	0.41	0.39

Table S5. TSS and total metal loads (particulate + dissolved). TSS loads given in kg and metal loads given in g.

Sample	TSS < 63 μm	TSS	Cr	Cu	Zn	Cd	Pb
	(kg)				(g)		
2018_0314	260	298	69.0	125	945	0.54	24.2
2018_0323	21.8	24.7	10.2	28.5	182	0.10	3.43
2018_0404	31.8	38.4	9.52	43.1	287	0.15	5.59
2018_0406	37.9	46.5	10.0	43.3	268	0.12	6.41
2018_0412	682	845	149	385	2617	1.78	103
2018_0720	9.28	39.9	6.93	18.1	149	0.10	5.60
2018_0828	368	538	161	122	1336	0.68	18.6
2018_0914	17.5	23.0	7.43	32.0	306	0.16	4.46
2018_0928	56.3	76.5	13.0	30.8	309	0.14	3.70
2018_1030	91.2	112	39.1	139	1989	0.64	8.21
2018_1107	45.5	53.0	16.5	96.3	1162	0.61	25.7

2018_1114	108	136	24.4	74.8	1201	0.65	7.15
2018_1127	19.9	29.4	3.45	23.1	395	0.13	2.97
2018_1205	478	555	132	223	2247	1.04	48.2
2018_1213	102	129	27.6	69.3	891	0.26	14.8
2018_1220	5.70	6.78	1.21	13.2	238	0.06	0.66
2019_0108	24.5	28.7	4.62	29.0	519	0.23	2.62

Table S6. Person correlation coefficients (r), t–test values and p–values for the correlation of TSS/TSS < 63µm and total metal (particulate + dissolved) loads as well as TSS/TSS < 63µm and mean metal treatment efficiencies (particulate + dissolved).

Correlation	r	t–Test Value	p–Value
Loads			
TSS < 63 µm & Cr	0.94	10.95	1.50E–08
TSS & Cr	0.96	13.53	8.22E–10
TSS < 63 µm & Cu	0.94	10.61	2.29E–08
TSS & Cu	0.92	9.10	1.69E–07
TSS < 63 µm & Zn	0.84	5.92	2.83E–05
TSS & Zn	0.82	5.54	5.63E–05
TSS < 63 µm & Cd	0.92	9.04	1.86E–07
TSS & Cd	0.91	8.27	5.75E–07
TSS < 63 µm & Pb	0.91	8.56	3.71E–07
TSS & Pb	0.89	7.59	1.64E–06
Mean Treatment Efficiencies			
TSS < 63 µm & Cr	0.87	6.75	6.57E–06
TSS & Cr	0.89	7.72	1.33E–06
TSS < 63 µm & Cu	0.83	5.67	4.46E–05
TSS & Cu	0.73	4.18	8.08E–04
TSS < 63 µm & Zn	0.85	6.18	1.77E–05
TSS & Zn	0.77	4.70	2.87E–04
TSS < 63 µm & Cd	0.82	5.52	5.88E–05
TSS & Cd	0.76	4.47	4.52E–04
TSS < 63 µm & Pb	0.64	3.25	5.38E–03
TSS & Pb	0.55	2.52	2.36E–02