

A CONTEMPORARY AND HISTORICAL ANALYSIS OF THE TRACE ELEMENT COMPOSITION OF SEWAGE SLUDGE IN THE UK

Jin Liu, Shan Liu, and Stephen R. Smith

Department of Civil and Environmental Engineering, Imperial College London, South Kensington Campus, London, SW7 2AZ, UK

Supporting Information

Annual total concentrations of Zn, Cu, Ni, Pb, Cd, Cr, Hg, Mo, As, Se and F in sewage sludge between 1989 and 2017 (mg/kg DS)

Zn				
Year	Mean	Median	Percentile 05	Percentile 95
1989	1309	1225	728	2510
1990	1307	1257	996	2630
1991	1323	1340	118	3170
1992	1399	1325	666	2210
1993	1189	1110	715	2790
1994	964	919	757	1300
1995	994	988	386	1630
1996	975	891	629	1675
1997	763	741	482	1090
1998	873	826	510	1229
1999	899	815	474	1560
2000	739	676	288	1420
2001	616	601	294	1029
2002	571	561	247	935
2003	553	561	235	847
2004	603	615	299	868
2005	560	548	288	897
2006	550	558	276	892
2007	571	558	296	920
2008	544	566	246	889
2009	549	586	250	846
2010	556	566	249	885
2011	584	627	260	870
2012	612	656	284	860
2013	630	669	254	949
2014	719	720	303	1200
2015	703	700	300	1070
2016	740	733	329	1140
2017	703	716	326	1013

Cu				
Year	Mean	Median	Percentile 05	Percentile 95
1989	389	363	230	613
1990	419	432	70.4	582
1991	464	450	322	656
1992	385	369	207	583
1993	324	314	32.0	461
1994	366	383	224	477
1995	479	429	297	1155
1996	539	428	224	1710
1997	420	402	212	724
1998	597	649	247	766
1999	538	544	202	796
2000	590	585	207	1088
2001	513	495	138	984
2002	489	460	171	899
2003	416	401	163	692
2004	447	427	157	809
2005	404	376	177	704
2006	380	346	141	721
2007	387	346	148	742
2008	364	328	140	720
2009	379	348	125	745
2010	403	373	126	802
2011	444	409	134	845
2012	443	403	156	878
2013	430	421	141	764
2014	419	397	152	772
2015	425	387	176	825
2016	413	397	145	749
2017	402	365	155	719

Ni				
Year	Mean	Median	Percentile 05	Percentile 95
1989	56.9	56.9	39.0	78.0
1990	51.4	48.0	20.7	87.0
1991	55.5	60.8	12.7	95.0
1992	57.2	58.2	19.6	73.4
1993	47.9	47.2	20.7	75.0
1994	39.7	32.0	19.2	68.6
1995	45.5	50.8	20.5	67.0
1996	41.4	34.8	18.0	78.3
1997	82.0	59.4	21.0	199
1998	47.1	33.7	21.8	116
1999	40.9	27.6	16.9	128
2000	34.5	29.2	9.48	79.5
2001	33.7	28.5	7.20	70.0
2002	31.6	26.0	4.51	62.7
2003	34.6	27.8	10.0	83.6
2004	28.9	24.1	3.00	69.8
2005	30.6	24.3	5.65	78.6
2006	26.9	22.0	3.00	63.2
2007	30.5	23.7	11.3	65.4
2008	24.4	18.6	3.00	56.7
2009	23.8	21.5	6.74	52.7
2010	23.0	19.9	8.80	48.8
2011	24.3	22.8	9.20	49.4
2012	24.3	22.1	10.1	47.1
2013	24.0	23.5	9.30	40.1
2014	30.6	27.3	11.4	47.8
2015	36.9	27.7	11.4	79.3
2016	27.5	24.2	9.20	47.2
2017	30.2	26.5	11.5	62.9

Pb				
Year	Mean	Median	Percentile 05	Percentile 95
1989	496	500	355	841
1990	574	535	367	1177
1991	535	525	285	733
1992	458	497	234	594
1993	488	455	41.0	780
1994	549	501	225	862
1995	513	486	258	769
1996	452	449	209	637
1997	269	201	141	550
1998	288	285	65.0	759
1999	240	228	45.4	551
2000	158	136	28.9	358
2001	153	128	30.0	364
2002	133	107	25.0	349
2003	117	95.1	30.0	278
2004	116	97.7	34.3	278
2005	96.6	80.7	26.1	229
2006	81.5	70.4	20.0	188
2007	79.9	72.3	23.9	175
2008	70.9	60.2	18.2	164
2009	68.8	53.6	15.5	142
2010	60.0	48.9	13.0	140
2011	60.6	44.5	15.6	138
2012	60.9	47.4	19.4	130
2013	60.4	47.5	19.0	147
2014	72.6	58.7	20.6	158
2015	74.4	56.6	17.8	159
2016	69.0	52.6	18.0	147
2017	68.3	56.4	20.4	139

Cd				
Year	Mean	Median	Percentile 05	Percentile 95
1989	7.20	7.10	3.80	12.0
1990	6.39	6.40	1.91	11.7
1991	7.57	7.80	1.50	12.4
1992	7.17	7.25	1.70	9.30
1993	5.25	5.70	2.60	9.70
1994	4.39	2.80	2.00	8.60
1995	5.20	4.97	2.30	9.80
1996	3.29	2.58	1.51	6.90
1997	2.94	2.19	1.11	7.28
1998	2.39	2.24	1.59	4.64
1999	2.67	2.46	1.00	5.14
2000	1.55	1.36	0.30	3.79
2001	1.48	1.25	0.30	3.74
2002	1.52	1.10	0.47	3.83
2003	1.31	1.10	0.47	2.51
2004	1.16	1.03	0.30	2.47
2005	1.24	1.08	0.51	2.42
2006	1.15	0.92	0.47	2.35
2007	1.25	1.05	0.49	2.68
2008	1.16	0.93	0.36	2.99
2009	0.83	0.77	0.30	1.80
2010	0.90	0.80	0.40	1.80
2011	0.92	0.90	0.40	1.60
2012	0.96	0.90	0.48	1.80
2013	0.94	0.90	0.40	1.69
2014	1.15	1.09	0.43	1.98
2015	1.14	0.97	0.40	2.20
2016	0.97	0.90	0.40	1.93
2017	1.00	0.90	0.40	1.90

Cr				
Year	Mean	Median	Percentile 05	Percentile 95
1989	1169	1070	771	2090
1990	1067	1120	121	2065
1991	1061	1190	12.2	2560
1992	1155	1105	446	2080
1993	733	771	67.1	1380
1994	463	450	57.2	1080
1995	521	482	30.6	1270
1996	383	102	57.3	994
1997	355	375	63.9	738
1998	130	75.8	28.2	502
1999	94.9	61.2	22.0	302
2000	75.6	58.6	16.1	176
2001	76.9	60.9	15.9	173
2002	66.6	50.0	15.0	185
2003	58.5	46.9	18.4	148
2004	58.6	45.7	19.0	158
2005	54.8	44.5	19.2	128
2006	47.0	39.9	14.3	123
2007	48.3	39.2	16.3	97.0
2008	40.1	32.1	8.50	83.6
2009	43.1	33.5	12.2	110
2010	39.4	29.5	12.1	104
2011	38.3	31.9	11.6	74.2
2012	37.8	32.3	13.0	81.0
2013	45.6	32.0	13.6	113
2014	79.0	39.8	15.9	160
2015	60.2	35.2	15.0	141
2016	55.4	34.5	14.5	101
2017	68.9	35.5	13.2	129

Hg				
Year	Mean	Median	Percentile 05	Percentile 95
1989	3.90	3.60	2.20	7.10
1990	5.15	3.60	1.50	14.3
1991	3.30	2.90	1.43	7.07
1992	2.56	2.48	1.51	4.01
1993	2.96	2.82	1.44	5.02
1994	2.42	2.38	1.10	3.69
1995	2.64	2.48	1.73	3.92
1996	2.07	2.03	0.51	3.86
1997	2.13	1.82	0.92	3.77
1998	2.86	2.86	0.94	4.68
1999	2.10	1.80	0.60	3.88
2000	2.21	1.92	0.60	4.42
2001	2.55	1.52	0.38	3.58
2002	2.08	1.79	0.59	4.26
2003	2.41	2.01	0.66	5.46
2004	2.36	2.11	0.83	4.82
2005	2.16	1.89	0.79	4.51
2006	1.53	1.19	0.47	3.59
2007	1.51	1.20	0.47	3.44
2008	1.08	0.99	0.40	2.18
2009	1.17	1.07	0.33	2.15
2010	1.08	1.00	0.30	2.10
2011	1.08	1.01	0.40	1.83
2012	1.06	0.99	0.40	1.90
2013	1.04	0.98	0.34	1.96
2014	0.95	0.85	0.36	1.74
2015	1.07	0.90	0.35	2.11
2016	0.98	0.90	0.32	1.81
2017	0.99	0.85	0.35	1.82

Mo				
Year	Mean	Median	Percentile 05	Percentile 95
1989	7.75	7.75	7.50	8.00
1990	16.4	16.0	6.50	27.2
1991	15.1	13.7	12.0	19.6
1992	10.0	10.0	10.0	10.0
1993	15.3	10.0	10.0	28.0
1994	14.3	10.0	5.00	34.0
1995	9.17	10.0	0.71	19.1
1996	15.4	10.9	10.0	27.2
1997	10.4	10.0	10.0	13.0
1998	9.69	10.0	5.81	12.1
1999	10.1	10.0	6.37	13.8
2000	5.58	4.28	3.00	10.9
2001	6.35	6.13	3.00	10.8
2002	7.12	6.92	3.00	13.0
2003	8.50	8.27	3.00	16.7
2004	7.00	6.08	3.00	15.0
2005	7.52	6.95	3.00	13.9
2006	7.11	6.02	3.00	15.8
2007	6.96	6.14	3.00	13.3
2008	6.77	6.14	3.00	12.9
2009	7.06	6.32	3.00	16.3
2010	6.57	6.05	2.20	13.2
2011	6.21	6.15	1.70	11.6
2012	6.16	6.20	2.10	10.9
2013	5.95	5.90	1.00	10.9
2014	7.19	7.00	1.80	12.8
2015	7.42	6.90	1.90	15.4
2016	6.83	6.60	2.50	13.5
2017	7.35	6.70	2.50	13.7

As				
Year	Mean	Median	Percentile 05	Percentile 95
1989	28.7	27.6	20.9	44.4
1990	17.5	16.9	0.30	35.8
1991	17.4	11.2	11.0	30.0
1992	25.9	25.9	10.0	41.8
1993	23.4	20.0	20.0	31.8
1994	15.4	17.0	5.00	26.2
1995	17.7	10.3	5.00	38.9
1996	16.4	10.0	7.50	31.0
1997	12.2	10.0	10.0	19.1
1998	8.15	10.0	2.17	15.4
1999	7.62	7.38	0.10	14.5
2000	5.81	4.88	1.32	10.0
2001	5.42	4.88	1.00	10.0
2002	9.92	1.85	1.00	10.0
2003	3.48	1.89	1.00	9.20
2004	2.78	1.00	1.00	8.89
2005	2.91	1.10	1.00	8.89
2006	4.24	4.30	1.00	9.46
2007	2.03	1.00	1.00	5.83
2008	4.21	3.95	1.00	7.99
2009	4.64	4.55	1.00	8.52
2010	4.59	4.40	1.60	7.50
2011	4.46	4.10	1.80	7.40
2012	4.81	4.29	2.15	8.10
2013	5.06	5.10	2.20	8.50
2014	5.66	5.18	2.40	10.6
2015	5.41	5.10	2.40	9.40
2016	5.47	5.30	2.40	9.10
2017	6.20	5.11	2.60	8.70

Se				
Year	Mean	Median	Percentile 05	Percentile 95
1989	1.90	1.90	1.50	2.30
1990	0.86	0.85	0.12	1.60
1991	10.0	10.0	10.0	10.0
1992	10.0	10.0	10.0	10.0
1993	2.80	1.88	1.59	10.0
1994	1.96	1.94	0.99	2.74
1995	1.97	1.88	1.08	3.14
1996	2.48	1.82	0.52	8.76
1997	3.82	1.87	1.05	17.4
1998	2.97	2.39	0.68	4.09
1999	1.77	1.76	0.10	3.76
2000	2.94	2.79	0.61	6.11
2001	2.67	2.28	0.50	5.30
2002	2.25	1.93	0.50	4.43
2003	2.67	2.33	0.75	5.00
2004	2.62	2.51	0.06	4.86
2005	2.70	2.25	0.64	5.45
2006	2.67	2.17	0.73	5.14
2007	3.41	3.23	1.14	5.72
2008	3.30	3.00	1.18	6.02
2009	3.74	3.37	1.18	6.97
2010	3.29	3.14	1.18	6.06
2011	3.00	2.83	1.13	5.52
2012	3.17	3.08	1.20	5.54
2013	3.28	3.36	1.20	5.03
2014	4.68	3.42	1.31	5.94
2015	3.87	3.31	1.27	5.90
2016	3.42	3.35	1.26	5.79
2017	3.21	2.98	1.15	5.23

F				
Year	Mean	Median	Percentile 05	Percentile 95
1989	274	274	142	406
1990	162	163	86.4	236
1991	195	195	89.0	300
1992	149	149	137	160
1993	253	225	160	435
1994	224	215	51.0	590
1995	199	195	78.0	308
1996	184	200	62.0	280
1997	220	212	55.0	343
1998	148	126	16.9	321
1999	174	150	40.0	400
2000	180	129	40.0	466
2001	200	157	42.0	477
2002	198	149	54.0	432
2003	210	159	44.0	516
2004	198	173	44.9	459
2005	201	176	51.1	448
2006	198	180	44.0	454
2007	181	164	68.0	397
2008	138	104	35.0	343
2009	155	101	35.0	393
2010	164	142	45.0	373
2011	188	133	55.0	379
2012	163	124	50.0	362
2013	164	130	41.0	461
2014	149	137	40.0	270
2015	162	142	54.1	329
2016	131	111	47.2	262
2017	128	104	49.0	274