

Supporting Information

Assessment of the long-term leaching behavior of incineration bottom ash: a study of two waste incinerators in Germany

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Table S1. pH values measured at the end of batch tests with samples stored outdoor and inside.

Sample A				Sample B			
	Time (days)	pH (L/S 10)	pH (L/S 2)		Time (days)	pH (L/S 10)	pH (L/S 2)
outdoor	0	12.32	12.53	outdoor	0	12.44	12.53
	1	11.92	12.39		4	12.27	12.56
	2	12.03	12.34		11	11.94	12.32
	5	12.07	12.19		19	11.65	12.03
	7	11.95	12.04		26	11.59	11.51
	14	11.86	11.93		32	11.43	11.37
	21	11.6	11.54		39	11.15	11.06
	28	11.61	11.68		46	10.96	10.72
	35	11.42	11.45		53	10.86	10.73
	42	11.23	11.21		60	10.73	10.6
	49	11.31	11.16		74	10.55	10.09
	56	10.92	10.71		88	10.75	10.29
	63	11.03	10.74		102	9.83	9.91
	70	10.59	10.18				
	77	10.52			0	12.41	12.54
	84	10.25	9.92		4	12.29	12.46
	126	9.72			11	12.08	12.45
	281	9.42	8.79		19	11.81	12.2
					26	11.71	11.77
	0	12.3	12.55		32	11.38	11.34
	1	12.03	12.46		39	11.23	11.03
	2	11.96	12.45		46	11.23	10.98
	5	12.09	12.17		53	10.92	10.7
	7	11.94	12.14		60	10.95	10.58
	14	11.83	12.09		74	10.83	10.35
	21	11.9	11.74		88	10.26	10.1
	28	11.55	11.56		102	10.15	9.78
	35	11.42	11.34				

Sample A				Sample B			
	Time (days)	pH (L/S 10)	pH (L/S 2)		Time (days)	pH (L/S 10)	pH (L/S 2)
	42	11.1	10.9	inside	0		
	49	11.24	10.96		4	12.44	12.54
	56	10.99	10.79		11	12	12.38
	63	10.96	10.67		19	11.82	12.13
	70	10.83	10.4		26	11.83	11.99
	77	10.85	10.41		32	11.66	11.57
	84	10.67	10.31		39	11.19	10.89
	126	9.92	9.39		46	11.17	10.93
	281	9.66	9.02		53		10.6
					60	11.32	11.13
inside	0	12.32	12.53		74	11.1	10.87
	7	12.03	12.16		88	11.06	10.71
	21	11.65	12.19		102	10.64	10.64
	42	11.71	11.85				
	63	11.63	11.66		0		
	84	11.51	11.48		4	12.36	12.56
	126	11.29	11.09		11	12.12	12.43
	281	10.6	9.91		19	11.84	12.16
					26	11.81	11.94
	0	12.3	12.55		32	11.54	11.51
	7	12	12.24		39	11.17	10.97
	21	11.9	12.14		46	11.22	10.91
	42	11.55	11.66		53	11.16	10.9
	63	11.63	11.69		60	11.11	10.83
	84	11.54	11.46		74	10.93	10.61
	126	11.02	10.81		88	11.01	10.67
	281	10.76	10.35		102	10.8	10.46

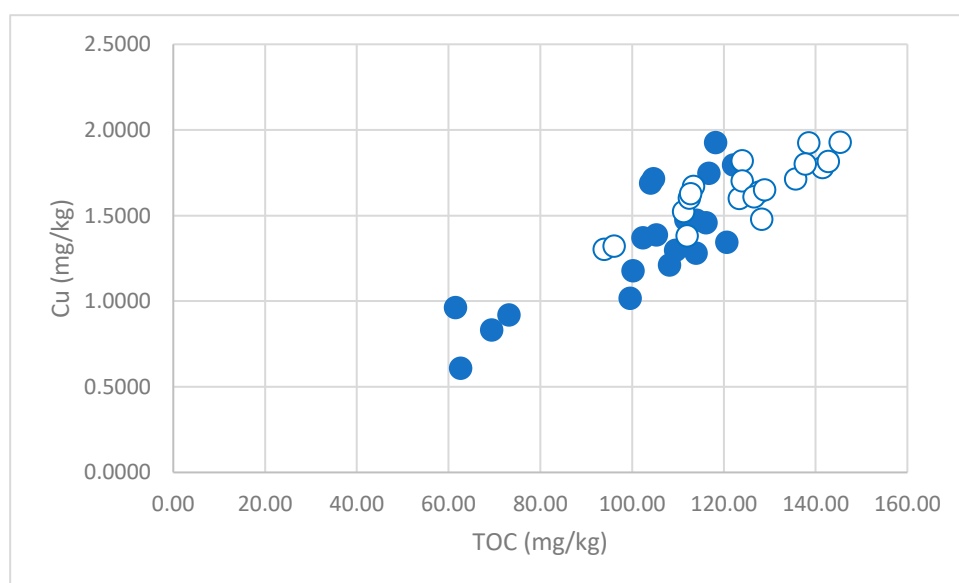


Figure S1. Measured release of copper as function of dissolved organic matter (sample B, L/S=2 L/kg, filled circles outdoor, unfilled circles indoor)

Table S2. Input parameters for modelling with Visual MINTEQ

Input		Debye-Hückel activity correction				
L/S=10 L/kg						
in solution	M (g/mol)	in solution	in solid	n(solv.)	n(solid)	sum
		mg/L	mg/0.1 kg			
Cu	63.6	0.05	150	7.86164E-07	0.00235849	2.36E-03
Zn	65.4	0.2	200	3.0581E-06	0.0030581	3.06E-03
Pb	207.2	0.1	50	4.82625E-07	0.00024131	2.42E-04
Sb	121.8	0.05	10	4.10509E-07	8.2102E-05	8.25E-05
Na	23	200		0.008695652	0	8.70E-03
Cl	35.5	650		0.018309859	0	1.83E-02
Ca	40	300		0.0075	0	7.50E-03
SO4	96	200		0.002083333	0	2.08E-03
Al	27	10	1500	3.70E-04	0.05555556	5.59E-02

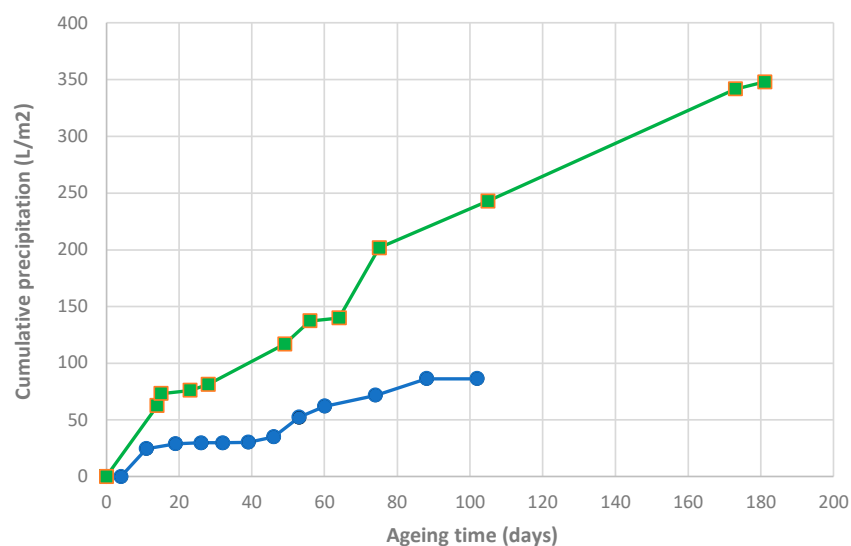


Figure S2. Rain fallen (cumulative) during outdoor storage of samples A (green squares) and B (blue circles).

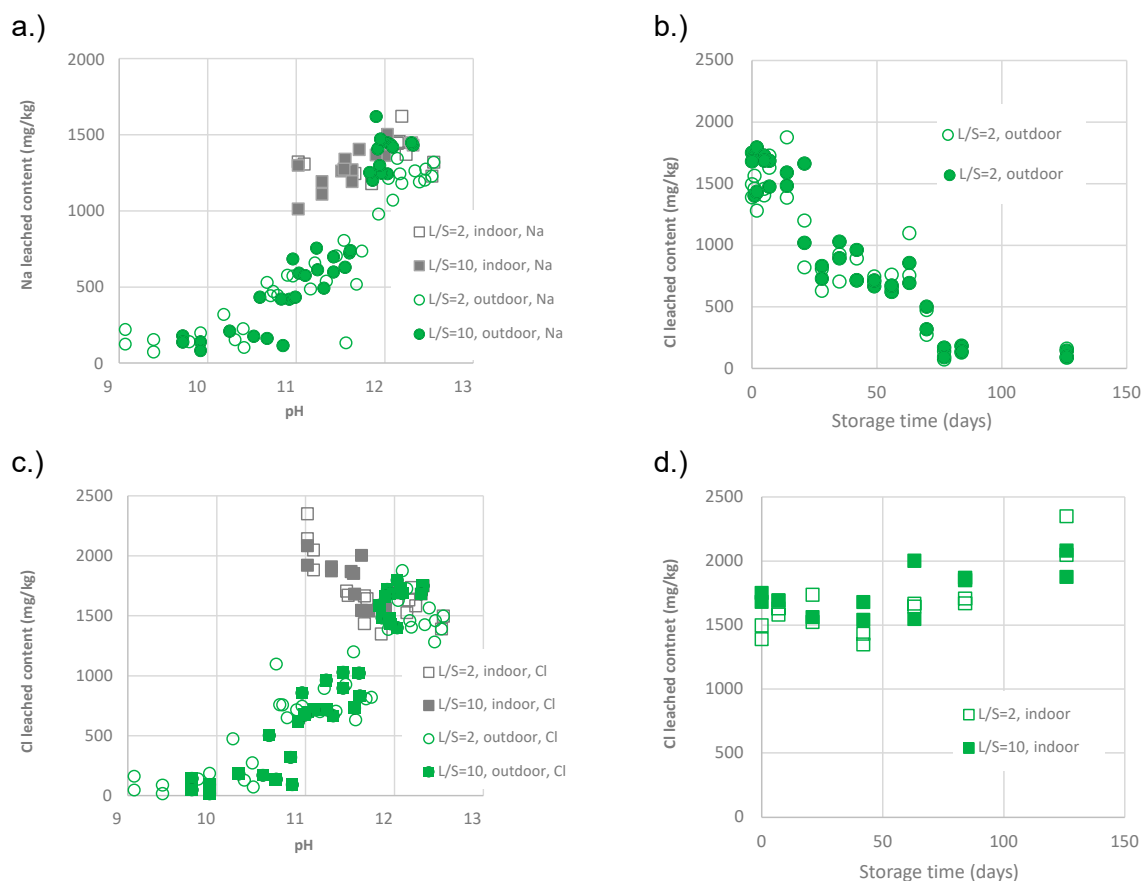


Figure S3. Released amount in mg/kg of Na (a) and Cl (b) as function of pH. The results from the samples stored indoor show that there is no pH dependence. Decreasing values are the result of wash out by rainfall. Released content of Cl as function of outdoor storage time (c) and storage time indoor (d). All results are from sample A.

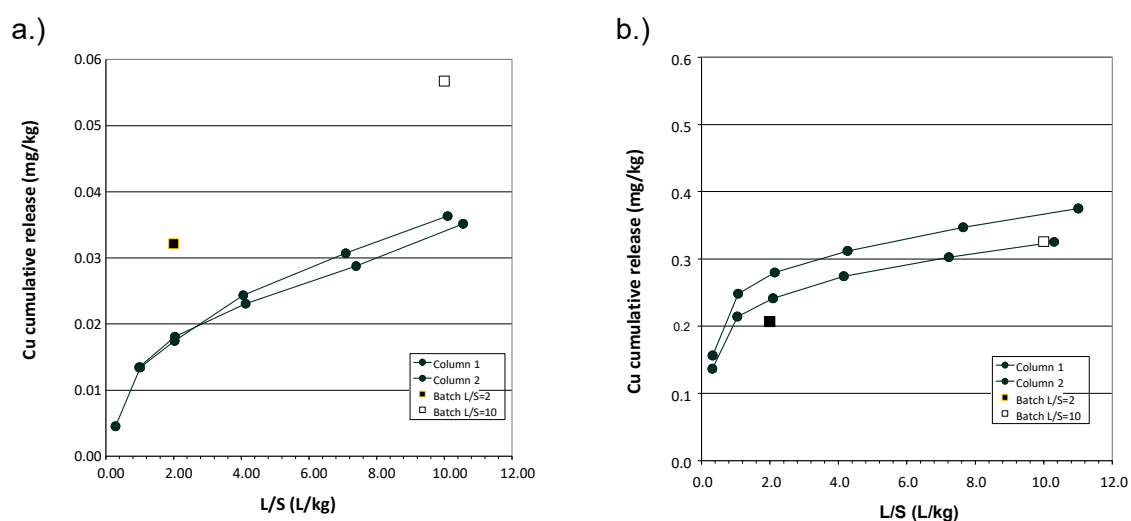
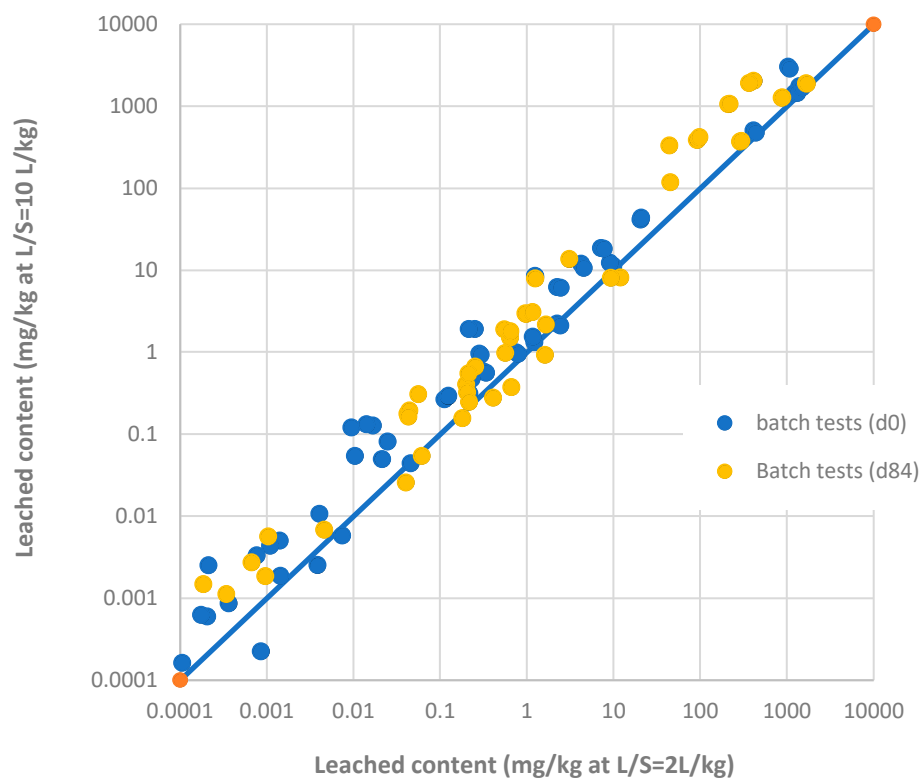


Figure S4. Cumulative release of Cu in a column test as function of the L/S ratio, sample B, unaged (a) and after 84 days storage time inside (b). The release is in both cases in the range of 400 $\mu\text{g/kg}$.



FigureS5. Plot of leached amount in batch tests at L/S=10 L/kg versus leached content at L/S=2 L/kg.

Table S3. Cumulative release (column test) resp. leached amount (batch test) in mg/kg for fresh (day 0) and aged (day 84) IBA sample A for various elements and anions. Duplicate analysis (1: lines 1-36, 2: lines 38-73).

Sample A		Fresh (day 0)				Aged (day 84)			
Parameter	Unit	Column test		Batch test		Column test		Batch test	
L/S	L/kg	2	10	2	10	2	10	2	10
As	mg/kg	0.00037449	0.00132958	0.00020626	0.0005998	0.00141082	0.01012052		
Ba	mg/kg	12.2004207	38.0219023	20.5917296	41.0761715	0.06402664	0.63576784	0.5495898	1.89186953
Cd	mg/kg	0	0			2.8941E-05	0.00075822	0.00018497	0.00147812
Cr	mg/kg	0.00812208	0.09167033	0.00957194	0.12104262	0.57656589	0.84787879	0.25460618	0.66268537
Cu	mg/kg	0.17459486	0.35145439	0.31462205	0.57865404	0.2414226	0.32531102	0.19931991	0.40434546
Hg	mg/kg	0.00046377	0.00138102	0.00021262	0.00252614	0.00143914		0.00095835	0.0018575
Mn	mg/kg	0	0.00187801		0.00258855	0.00084349	0.0084969		
Mo	mg/kg	0.16433013	0.40423548	0.11235153	0.26605172	0.26768255	0.33972805	0.20479069	0.3229046
Ni	mg/kg	0.00257616	0.00257616	0.0014161	0.00506795	0.00126838	0.02337609		0.02504946
Pb	mg/kg	0.37717028	1.56819879	1.22107774	1.33019455	0	0.01532818		
Sb	mg/kg	0.00414342	0.11139327	0.01672522	0.12676181	0.05067979	0.68996408	0.0559901	0.30550111
Sn	mg/kg	0.00128347	0.00467475	0.00388802	0.00253332	0.01040572	0.05575033	0.0045804	0.00682421
Sr	mg/kg	7.23490919	13.0085007	9.99307075	11.2581648	0.82841128	2.86772486	0.9784569	2.91676506
V	mg/kg	0.00015093	0.00322112			0.01104408	0.03994021		
Zn	mg/kg	0.06548638	0.83622878	0.25122232	1.91001495	0	0.11824122	0.04218758	0.17676207
Co	mg/kg	0.00015641	0.00052012	0.00010605	0.00016232	0.00066843	0.00434261		
Al	mg/kg	1.07339597	63.9628078	0.65075238	45.0130154	71.4018127	261.766398	44.0027411	332.496517
Ca	mg/kg	1136.48215	3954.96799	1036.27357	2987.95961	212.389279	798.573316	209.80507	1059.51146
Fe	mg/kg	0	0	0.0008633	0.00022422	0	37.5332278		
K	mg/kg	417.969435	509.875039	407.975941	503.361271	343.828825	475.191407	289.262242	369.198697
Mg	mg/kg	0	0	0.00746053	0.00581852	0.09514308	0.09514308		
Na	mg/kg	1157.74549	1322.07662	1228.71884	1433.11411	1234.82571	1358.15534	874.622021	1262.90361
B	mg/kg	0	0.24258268	0.02462218	0.08156653	0.16999348	0.92706543	0.63936204	1.50878837
P	mg/kg	0.71917963	0.96565669	0.75335877	0.99235664	0.31814944	0.3552943	1.65975916	2.17259425
S	mg/kg	9.13242558	36.6056754	4.21120923	11.921107	258.109572	365.059629	91.6889469	383.220327

Sample A		Fresh (day 0)				Aged (day 84)			
Parameter	Unit	Column test		Batch test		Column test		Batch test	
L/S	L/kg	2	10	2	10	2	10	2	10
Se	mg/kg	0.00109105	0.00317603	0.00143192	0.00187075	0.00659785		0.04402622	0.19419707
Si	mg/kg	0	0	1.25107752	8.37677072	0	0	1.25833974	7.90745306
Ti	mg/kg	0.25830059	0.87751578	0.28653371	0.96252611	0.06113233	0.22641486		
Tl	mg/kg	2.803E-05	2.803E-05		0.00014391				
Fluoride	mg/kg								
Chloride	mg/kg	1358.71745	1723.71144	1389.36429	1752.14226	2197.7652	2369.12739	1670.52793	1869.23056
Nitrit	mg/kg	2.50176343	3.35994894	2.23474109	6.22279266			0.6673982	0.37454166
Bromide	mg/kg	2.55601751	2.56145533	2.23142774	2.2082475	37.5714037	37.8093001	12.0113282	8.13338132
Nitrate	mg/kg	0.10901881	0.10901881	0.21706673	0.31104441				
Sulfate	mg/kg	21.958757	79.608448	7.16051264	18.5226613	959.617137	1311.15485	413.873884	2027.33445
Phosphate	mg/kg					4.03305822	8.00501852	3.08811807	13.5977121
As	mg/kg	0.00048343	0.00133825	0.00017431	0.00062466	0.00184786	0.00613723		
Ba	mg/kg	13.3377687	37.6282985	20.9325277	43.7437299	0.07558724	0.78057299	0.64466305	1.79403981
Cd	mg/kg	0	0		0.000475	1.9666E-05	1.9666E-05	0.00034113	0.00112496
Cr	mg/kg	0.00959197	0.09706546	0.01040719	0.05417607	0.59385635	0.91714145	0.21181995	0.55131064
Cu	mg/kg	0.18091939	0.36330255	0.3391087	0.55899136	0.27991559	0.37513332	0.21511979	0.2473089
Hg	mg/kg	0.00041403	0.0023983	0.00014574		0.00183859	0.0081409	0.00066535	0.00273839
Mn	mg/kg	0	0.00317754		0.00132414	0.00112	0.00759934	2.5987E-05	
Mo	mg/kg	0.16512512	0.39459541	0.12459954	0.29091152	0.32129451	0.41353338	0.1799204	0.15671221
Ni	mg/kg	0.00257616	0.00257616	0.00110044	0.00433812	0.00152926	0.12415834	0.00283821	
Pb	mg/kg	0.46283388	1.43356125	1.17305275	1.54188298	0.00017225	0.00186682		
Sb	mg/kg	0.00137512	0.10963396	0.0142272	0.13220908	0.07759631	0.40932217	0.04303271	0.16419891
Sn	mg/kg	0.00128347	0.00516417	0.004067	0.01064607	0.00465767	0.04697978	0.00103495	0.00563394
Sr	mg/kg	7.18809208	13.1584368	9.09013184	12.2890545	0.78464285	3.20022275	0.96660329	2.97458844
V	mg/kg	0.00015093	0.00394017		0.00222336	0.01162817	0.04226116		
Zn	mg/kg	0.10111185	0.84380566	0.21348988	1.92276836	0	0.08625365	0.04003732	0.02564662
Co	mg/kg	0.00015738	0.00064661	9.4881E-05	0.000132	0.00078117	0.00224805		

Sample A		Fresh (day 0)				Aged (day 84)			
Parameter	Unit	Column test		Batch test		Column test		Batch test	
L/S	L/kg	2	10	2	10	2	10	2	10
Al	mg/kg	1.05881404	56.8265764	0.54935352	64.191654	88.9739667	306.882591	45.3207322	118.31534
Ca	mg/kg	1171.52829	3849.97703	1076.17633	2862.14656	192.654248	852.429716	218.228735	1064.27811
Fe	mg/kg	0	0	0.00036475	0.00086279	0	0		
K	mg/kg	416.250626	510.458626	439.902834	473.29697	358.248003	501.297259	298.432354	376.349013
Mg	mg/kg	0	0	0.04571632	0.04420201	0.10953631	0.10953631		
Na	mg/kg	1157.14638	1315.08339	1321.05312	1448.50709	1264.77238	1391.4947	888.956685	1273.92523
B	mg/kg	0	0.17040523	0.02145822	0.0495105	0.2307624	1.08138517	0.56626311	0.97548531
P	mg/kg	0.72637364	0.90307001	0.79112113	0.94911988	0.36405938	0.45398241	1.62359615	0.92772898
S	mg/kg	8.95988683	38.7106641	4.52598624	10.5463668	256.790882	361.469641	97.8445148	417.032229
Se	mg/kg	0.00109105	0.00378624	0.00076546	0.0033121	0.00818415	0.0128204	0.06158761	0.05444828
Si	mg/kg	0	0	1.24741144	8.42404929	0	0	1.16639974	3.09578033
Ti	mg/kg	0.27914381	0.85409743	0.29294182	0.92343859	0.05800426	0.23695412		
Tl	mg/kg	2.803E-05	2.803E-05		6.6232E-05				
Fluoride	mg/kg								
Chloride	mg/kg	1371.37257	1709.1953	1496.96992	1682.03876	2202.32528	2405.47034	1705.75816	1852.5241
Nitrit	mg/kg	2.44308203	3.41367638	2.45022134	6.1005772			0.40968696	0.27841673
Bromide	mg/kg	2.56145533	2.55601751	2.44256473	2.12010945	35.7548413	36.1408724	9.30000105	8.04982336
Nitrate	mg/kg	0.10901881	0.10901881	0.23280801	0.47180247				
Sulfate	mg/kg	21.2791885	80.9949205	7.73288996	18.3109124	917.31531	1258.54245	366.764431	1889.92572
Phosphate	mg/kg					4.14906498	7.02707382		13.8190042