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APPENDICES

APPENDIX A

Temperature during experiment

Table A-1 Temperature during experiment

Day	Temperature	Day	Temperature	Day	Temperature
1	31.0	43	30.0	85	32.0
2	32.0	44	29.5	86	32.5
3	31.0	45	30.0	87	32.5
4	29.0	46	30.0	88	33.0
5	30.0	47	30.0	89	32.5
6	30.5	48	27.5	90	32.0
7	30.0	49	29.0	91	30.5
8	31.0	50	30.5	92	31.5
9	30.0	51	31.0	93	32.0
10	30.0	52	30.5	94	32.0
11	29.0	53	30.5	95	32.0
12	30.0	54	31.0	96	32.5
13	30.0	55	30.8	97	32.0
14	31.0	56	31.0	98	31.8
15	30.5	57	31.0	99	31.5
16	30.0	58	31.0	100	33.0
17	29.0	59	31.0	101	32.0
18	30.0	60	31.0	102	32.0
19	31.0	61	30.5	103	31.5
20	30.5	62	29.7	104	32.0
21	31.0	63	29.5	105	31.5
22	30.5	64	30.0	106	31.5
23	30.2	65	30.0	107	31.0
24	31.0	66	30.0	108	31.5
25	31.5	67	31.0	109	30.5
26	30.0	68	30.5	110	30.0
27	30.0	69	30.8	111	30.0
28	29.5	70	30.0	112	30.5
29	30.2	71	29.0	113	30.0
30	29.0	72	29.5	114	30.5
31	29.0	73	29.0	115	30.5
32	31.0	74	32.0	116	30.5
33	30.0	75	30.0	117	31.0
34	30.0	76	31.0	118	30.5
35	30.0	77	30.0	119	31.0
36	29.5	78	30.5	120	30.5
37	28.8	79	31.2	121	29.5
38	29.0	80	31.5	122	30.0
39	29.0	81	32.0	123	30.0
40	29.0	82	32.5	124	29.5
41	29.0	83	33.0	125	29.0
42	30.0	84	32.5	126	29.0

Table A-1 Temperature during experiment (Cont.)

Day	Temperature	Day	Temperature
127	29.0	169	30.5
128	28.0	170	30.0
129	28.0	171	32.0
130	28.0	172	31.2
131	28.0	173	31.5
132	29.0	174	31.0
133	29.0	175	30.5
134	30.0	176	29.5
135	30.0	177	29.0
136	30.0	178	29.0
137	29.5	179	28.0
138	28.0	180	26.5
139	29.0	181	29.5
140	30.0	182	29.0
141	29.5	183	29.8
142	30.0	184	28.5
143	30.5	185	28.2
144	31.0	186	28.5
145	31.5	187	31.0
146	31.0	188	32.0
147	32.0	189	29.5
148	32.0	190	31.0
149	31.5	191	31.0
150	31.0	192	30.5
151	29.5	193	30.5
152	30.0	194	31.0
153	30.0	195	30.5
154	30.0		
155	30.0		
156	30.5		
157	30.5		
158	31.5		
159	30.0		
160	31.0		
161	30.0		
162	29.5		
163	29.5		
164	29.5		
165	30.0		
166	31.0		
167	31.0		
168	31.5		

APPENDIX B

Leachate analysis data from the simulated landfill reactors

Table B-1 pH during experiment

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
1	3.88	3.90	3.95	38	5.24	5.16	5.12
2	3.87	3.92	3.95	39	5.22	5.16	5.13
3	3.88	3.94	3.97	40	5.22	5.16	5.13
4	3.89	3.98	3.96	41	5.20	5.12	5.15
5	3.91	4.01	4.01	42	5.18	5.12	5.10
6	3.92	4.05	4.01	43	5.20	5.12	5.09
7	3.93	4.11	3.98	44	5.19	5.13	5.10
8	3.93	4.11	3.96	45	5.19	5.11	5.09
9	3.97	4.18	3.97	46	5.20	5.13	5.13
10	4.03	4.29	3.99	47	5.22	5.12	5.11
11	4.12	4.37	4.03	48	5.19	5.10	5.10
12	4.55	4.45	4.06	49	5.16	5.06	5.07
13	4.56	4.65	4.14	50	5.16	5.07	5.07
14	5.23	4.68	4.12	51	5.16	5.06	5.00
15	5.21	4.78	4.18	52	5.16	5.06	5.06
16	5.19	4.81	4.27	53	5.20	5.09	5.09
17	5.18	4.85	4.32	54	5.15	5.06	5.07
18	5.20	4.90	4.43	55	5.21	5.11	5.12
19	5.20	4.93	4.88	56	5.19	5.10	5.11
20	5.24	5.00	5.13	57	5.19	5.09	5.12
21	5.20	5.01	5.14	58	5.21	5.10	5.13
22	5.15	5.01	5.14	59	5.17	5.07	5.10
23	5.14	5.02	5.13	60	5.17	5.05	5.08
24	5.14	5.05	5.13	61	5.17	5.05	5.08
25	5.14	5.06	5.11	62	5.21	5.10	5.12
26	5.14	5.07	5.10	63	5.21	5.11	5.12
27	5.16	5.10	5.10	64	5.19	5.08	5.10
28	5.17	5.12	5.12	65	5.21	5.10	5.12
29	5.14	5.10	5.08	66	5.19	5.06	5.08
30	5.16	5.11	5.08	67	5.25	5.12	5.14
31	5.17	5.11	5.07	68	5.24	5.11	5.13
32	5.18	5.13	5.11	69	5.20	5.04	5.07
33	5.20	5.16	5.13	70	5.17	5.08	5.10
34	5.19	5.15	5.10	71	5.20	5.08	5.11
35	5.22	5.19	5.13	72	5.20	5.09	5.09
36	5.20	5.14	5.08	73	5.19	5.07	5.07
37	5.21	5.16	5.12	74	5.18	5.06	5.07

Table B-1 pH during experiment (Cont.)

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
75	5.15	5.02	5.04	112	5.21	5.11	5.10
76	5.19	5.06	5.09	113	5.19	5.08	5.10
77	5.14	5.01	5.03	114	5.15	5.07	5.07
78	5.14	5.01	5.04	115	5.15	5.07	5.11
79	5.16	5.05	5.05	116	5.17	5.08	5.11
80	5.18	5.05	5.05	117	5.17	5.09	5.08
81	5.16	5.05	5.06	118	5.14	5.06	5.05
82	5.16	5.05	5.07	119	5.14	5.06	5.06
83	5.16	5.05	5.06	120	5.14	5.12	5.06
84	5.15	5.04	5.05	121	5.18	5.12	5.11
85	5.15	5.07	5.06	122	5.16	5.12	5.11
86	5.15	5.09	5.06	123	5.15	5.12	5.13
87	5.23	5.1	5.12	124	5.15	5.07	5.06
88	5.17	5.07	5.05	125	5.15	5.09	5.06
89	5.15	5.04	5.04	126	5.23	5.1	5.12
90	5.15	5.06	5.05	127	5.16	5.1	5.09
91	5.16	5.05	5.05	128	5.19	5.12	5.12
92	5.15	5.06	5.06	129	5.19	5.1	5.12
93	5.16	5.09	5.1	130	5.2	5.1	5.12
94	5.16	5.09	5.1	131	5.21	5.13	5.13
95	5.17	5.09	5.08	132	5.17	5.11	5.13
96	5.16	5.07	5.08	133	5.16	5.09	5.08
97	5.15	5.05	5.06	134	5.14	5.05	5.09
98	5.15	5.05	5.06	135	5.25	5.09	5.09
99	5.16	5.05	5.07	136	5.29	5.11	5.29
100	5.18	5.07	5.07	137	5.28	5.13	5.29
101	5.2	5.08	5.10	138	5.28	5.15	5.28
102	5.19	5.08	5.09	139	5.29	5.24	5.28
103	5.15	5.07	5.07	140	5.29	5.31	5.28
104	5.14	5.08	5.06	141	5.29	5.32	5.33
105	5.14	5.08	5.06	142	5.35	5.35	5.19
106	5.17	5.08	5.08	143	5.22	5.22	5.19
107	5.19	5.08	5.09	144	5.19	5.19	5.18
108	5.17	5.14	5.08	145	5.18	5.19	5.17
109	5.18	5.08	5.08	146	5.17	5.17	5.17
110	5.22	5.11	5.11	147	5.16	5.16	5.18
111	5.16	5.06	5.04	148	5.13	5.15	5.15

Table B-1 pH during experiment (Cont.)

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
149	5.12	5.15	5.20	185	6.46	6.76	6.45
150	5.10	5.18	5.24	186	6.63	6.87	6.55
151	5.18	5.26	5.32	187	6.64	6.90	6.74
152	5.24	5.21	5.31	188	6.75	6.90	6.91
153	5.15	5.20	5.27	189	6.82	6.94	6.93
154	5.19	5.22	5.23	190	6.84	7.00	
155	5.24	5.19	5.18	191	6.70	6.93	
156	5.26	5.18	5.16	192	6.81	7.00	
157	5.29	5.16	5.11	193	6.94	7.01	
158	5.30	5.15	5.09	194	7.02	7.02	
159	5.35	5.19	5.11	195	7.10	7.03	
160	5.36	5.19	5.12				
161	5.35	5.21	5.14				
162	5.37	5.24	5.15				
163	5.38	5.23	5.17				
164	5.39	5.25	5.16				
165	5.45	5.26	5.25				
166	5.42	5.29	5.22				
167	5.45	5.28	5.27				
168	5.50	5.35	5.23				
169	5.53	5.38	5.28				
170	5.55	5.40	5.30				
171	5.60	5.43	5.31				
172	5.60	5.43	5.33				
173	5.73	5.48	5.38				
174	5.87	5.65	5.51				
175	5.97	5.69	5.58				
176	6.08	5.78	5.64				
177	6.13	5.85	5.67				
178	6.18	5.92	5.74				
179	6.22	6.08	5.79				
180	6.20	6.08	5.81				
181	6.38	6.40	5.91				
182	6.36	6.55	5.93				
183	6.48	6.71	6.19				
184	6.54	6.77	6.33				

Table B-2 COD during experiment

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
1	50800	39466	39466	172	50800	39466	39466
4	60000	40800	36800	174	60000	40800	36800
7	59031	52800	46613	176	59031	52800	46613
10	54800	50800	50134	179	54800	50800	50134
16	50134	49466	45466	181	31673	33555	33555
22	37466	42800	46134	186	26342	25715	32614
25	38800	41466	43367	189	27596	29244	32920
28	48800	49466	46800	195	26112	27365	29491
31	49852	56800	53394	189	27596	29243	32920
34	30088	48767	37666	195	26112	27365	29491
40	36769	59352	40009				
48	63025	49114	48474				
55	43200	48640	44160				
63	46400	51200	38400				
67	49000	46400	43200				
81	56000	47000	48000				
91	36800	44800	48000				
102	48000	46400	38400				
113	48000	52000	43840				
120	43520	45568	40192				
126	30208	31232	35840				
131	32768	32256	32768				
133	27648	31232	30720				
138	31232	33280	30720				
144	36352	35328	32768				
147	40448	31232	35328				
148	30208	32512	30976				
151	37888	35072	32512				
153	32614	35123	39827				
155	26969	29792	46726				
159		41081	43904				
161	29792	38259	38886				
165		37005	35437				
168	26342	34496	33555				

Table B-3 ORP during experiment

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
99	-76.6	-145.8	-163.4	135	-173.4	-177.7	-166.9
100	-149.5	-157.6	-155.1	136	-217.8	-204.6	-215.2
101	-124.6	-69.6	-121.6	137	-184.0	-179.9	
102	-96.0	-78.4	-82.9	138	-173.2	-154.8	
103	-131.8	-107.8	-125.9	139	-199.2	-179.6	
104	-151.6	-101.0	-133.2	140	-146.2	-154.8	
105	-124.5	-105.0		141	-136.5	-114.5	-151.5
106	-68.8	-110.1	-80.5	142	-156.4	-146.8	
107	-148.8	-148.0	-155.9	143	-148.2	-133.7	-143.9
108	-165.8	-96.2	-168.2	144	-133.3	-137.3	-141.3
109	-181.1	-147.1	-168.3	145	-128.6	-131.9	-138.4
110	-65.0	-142.1	-55.4	146	-137.2	-176.3	-163.6
111	-156.6	-140.1	-149.2	147	-154.6	-155.5	-194.2
112	-167.2	-144.0	-149.5	148	-133.9	-147.3	-181.3
113	-162.7	-43.7	-79.6	149	-138.4	-142.4	-181.6
114	-159.5	-149.6	-148.3	150	-158.9	-186.4	-227.5
115	-130.0	-152.0		151	-160.8	-208.2	-231.0
116	-102.0	-173.9	-173.9	152	-213.2	-187.9	-233.8
117	-148.1	-101.9	-121.4	153	-180.7	-181.1	-198.9
118	-181.1	-175.4	-164.6	154	-165.7	-163.8	-222.5
119	-160.2	-142.2	-123.1	155	-170.7	-156.8	-174.2
120	-124.0	-95.7	-63.8	156	-174.2	-176.1	-155.3
121	-132.8	-93.0	-101.3	157	-173.3	-203.9	-227.0
122	-145.0	-121.0		158	-132.2	-189.9	
123	-193.0	-158.6	-147.5	159	-128.2	-199.7	-153.4
124	-145.1	-85.1	-88.9	160	-140.7	-183.6	-154.5
125	-134.0	-134.5		161	-127.9	-181.1	-191.5
126	-123.7	-20.9	-6.0	162	-125.7	-192.4	-148.8
127	-181.0	-128.6	-166.9	163	-135.8	-203.5	-178.5
128	-145.6	-131.3	-167.4	164	-138.1	-203.2	-203.8
129	-132.4	-153.6		165	-124.4	-223.9	-215.4
130	-160.2	-189.4		166	-127.6	-187.1	-199.3
131	-120.3	-126.0	-138.7	167	-124.4	-187.7	-196.6
132	-143.0	-132.4		168	-140.7	-165.8	-188.1
133	-132.2	-123.0	-129.9	169	-158.3	-201.8	-194.4
134	-232.1	-203.6	-171.1	170	-143.8	-203.6	-190.1

Table B-3 ORP during experiment (Cont.)

Day	Reactor 1	Reactor 2	Reactor 3
171	-149.8	-218.5	-211.0
172	-146.0	-198.6	-181.9
173	-139.9	-198.2	-177.7
174	-152.8	-197.3	-148.0
175	-157.5	-197.3	-166.0
176	-166.9	-202.2	-205.8
177	-163.2	-207.8	-211.1
178	-156.3	-202.2	-222.9
179	-172.0	-212.7	-222.1
180	-180.6	-232.3	-202.9
181	-156.2	-182.2	-216.7
182	-123.4	-169.3	-198.0
183	-149.6	-193.0	-243.7
184	-177.6	-207.8	-239.0
185	-170.9	-215.8	-251.5
186	-243.8	-210.6	-266.4
187	-230.0	-183.0	-289.3
188	-227.1	-274.5	-327.6
189	-339.4	-300.1	-360.6
190	-315.2	-289.3	-368.2
191	-330.5	-323.1	-368.2
192	-329.6	-340.6	-379.7
193	-327.0	-336.5	
194	-328.0	-327.5	
195	-319.7	-297.6	

Table B-4 Orthophosphate during experiment

Day	Reactor 1	Reactor 2	Reactor 3
13	255.00	245.00	204.00
50	608.50	620.42	617.44
77	659.51	648.70	652.63
116	114.00	114.00	184.00
158	214.00	306.00	306.00
188	184.00	842.00	765.00

Table B-5 Ammonia nitrate during experiment

Day	Reactor 1	Reactor 2	Reactor 3
13	420.00	380.00	381.00
50	1171.80	1360.80	1423.80
77	1310.85	1310.85	1287.44
116	2278.00	1549.00	1614.00
158	483.00	734.00	969.00
188	1234.00	1161.00	1292.00

Table B-6 Sulfide and sulfate during experiment

Day	Sulfide		Sulfate	
	Reactor 1	Reactor 2	Reactor 1	Reactor 2
13	1.20	2.10	124.00	162.00
28	1.30	1.00	184.00	287.00
77	1.42	0.61	1005.13	947.91
116	0.90	1.10	698.00	344.00
158	0.90	0.90	37.00	45.00
188	0.20	1.70	56.00	58.00

Table B-7 Alkalinity during experiment

Day	Reactor 1	Reactor 2	Reactor 3
33	4100	4800	4000
48	2600	2800	2600
61	3700	3600	3100
106	4200	4300	3900
110	4900	5400	4800
124	4600	4400	3650
147	4020	4380	5880
172	5950	7100	6690
181	7260	9200	8610
195	7560	9400	10350

APPENDIX C

Gas analysis data from the simulated landfill reactors

Table C-1 Daily gas production during experiment

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
1	4915	3850		37	340	650	1190
2	2540	1320		38	1290	2340	2640
3	3400	2520		39			1550
4	4120	2180		40	1590	2660	2600
5	5060	4840	1700	41	610	610	700
6	5720	6140	1610	42	810	2050	2230
7	6860	9740	1900	43	210	1450	1510
8	5540	6280	1280	44	1290	1660	1950
9	6340	6960		45	1130	1820	1940
10	5420	5370	5520	46	520	550	800
11	10840	8000	3160	47	90	500	820
12	23860	11800	624	48			
13	7140	8440	4180	49	990	1380	2020
14	10680	20040	10240	50	1440	1860	2110
15	5020	4140	6280	51	1410	1480	
16	8100	3720	12100	52	100	220	300
17			12600	53	1350	1500	2140
18	4490	2240	16140	54	280	280	500
19	5190	4340	28100	55	1440	1350	1130
20	4610	5310	8920	56	1100	730	1320
21	2410	5520	5330	57	1200	1200	1440
22	5120	8060	10200	58	1190	1140	1460
23	2050	4270	5720	59	640	400	860
24	2050	4790	5450	60	520	520	900
25	4140	7210	7260	61			
26	5160	7650	6950	62			
27		2280	1680	63			
28	730	3610	2440	64			
29	3050	5040	3960	65	60	40	230
30	780	1040	1920	66	670	280	680
31	580	2040	1560	67	1800	1600	1840
32	2190	5130	3150	68			
33	1400	3050	2880	69			
34	1500	2890	2610	70			
35	1200	2380	2250	71			
36	430	1270	1490	72	60		

Table C-1 Daily gas production during experiment (Cont.)

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
73	30		40	109			
74	1940	1560	1890	110			
75	180	110	730	111			
76	1350	1360	1660	112	890	730	360
77				113			
78			100	114	460		
79				115			
80	450			116			
81	120	480	320	117	830	270	130
82	2120	1610	2010	118	620	520	530
83	1690	1320	1620	119			
84				120			
85	530		400	121			
86	830	540	1080	122			
87	170	20	120	123			
88	930	780	1080	124			
89				125			
90	180		350	126	950	1050	470
91				127			
92				128			
93	1500	1090	1170	129			
94	1070	860	1110	130			
95	800	500	620	131	1100	1380	330
96	1340	580	740	132			
97				133			
98	30			134			
99				135			480
100	2980	2240	1600	136	710		1260
101				137			
102	30		50	138			
103				139			
104	660		310	140			
105				141			
106	1050	270	880	142			
107				143	280	190	70
108	850	640	650	144			

Table C-1 Daily gas production during experiment (Cont.)

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
145		230	740	180	640	1640	1780
146				181	1515	5000	3160
147	2300	1880	1840	182	1160	1720	4440
148	1090	1030	810	183	1100	4600	5850
149	300	360	60	184	1020	1100	4880
150	230	1340	580	185	1030	5590	6100
151	180	1220	940	186	1200	1680	5240
152	160	100	40	187	1160	1290	1020
153			2570	188	1420	3790	1500
154	1640	2280	1770	189	1540	1080	1650
155	1230	2480	4840	190	1540	1040	1530
156	540	1340	2580	191	1160	740	1640
157	2820	100	2300	192	1090	3540	2000
158	1250		3370	193	1120	2720	1980
159	1700	660	2400	194	1480	2480	1780
160	2080	480	4480	195	1660	1410	980
161	1520	350	3500				
162	1950	650					
163	2250	740	2560				
164	420	540	1100				
165	1360	720	3130				
166	1920	1440	2165				
167	1200	680	1820				
168	2440	1890	7000				
169	1100	860	2100				
170	1000	900	2900				
171	1000	650	3600				
172	1405	660	4320				
173	1300	660	1780				
174	140	160	480				
175	1220	660	2100				
176	870	700	1860				
177	120	160	760				
178	300	3940	840				
179	1030	5450	3210				

Table C-2 Cumulative gas production during experiment

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
1	4915	3850		37	162975	184110	180394
2	7455	5170		38	164265	186450	183034
3	10855	7690		39	164265	186450	184584
4	14975	9870		40	165855	189110	187184
5	20035	14710	1700	41	166465	189720	187884
6	25755	20850	3310	42	167275	191770	190114
7	32615	30590	5210	43	167485	193220	191624
8	38155	36870	6490	44	168775	194880	193574
9	44495	43830	6490	45	169905	196700	195514
10	49915	49200	12010	46	170425	197250	196314
11	60755	57200	15170	47	170515	197750	197134
12	84615	69000	15794	48	170515	197750	197134
13	91755	77440	19974	49	171505	199130	199154
14	102435	97480	30214	50	172945	200990	201264
15	107455	101620	36494	51	174355	202470	201264
16	115555	105340	48594	52	174455	202690	201564
17	115555	105340	61194	53	175805	204190	203704
18	120045	107580	77334	54	176085	204470	204204
19	125235	111920	105434	55	177525	205820	205334
20	129845	117230	114354	56	178625	206550	206654
21	132255	122750	119684	57	179825	207750	208094
22	137375	130810	129884	58	181015	208890	209554
23	139425	135080	135604	59	181655	209290	210414
24	141475	139870	141054	60	182175	209810	211314
25	145615	147080	148314	61	182175	209810	211314
26	150775	154730	155264	62	182175	209810	211314
27	150775	157010	156944	63	182175	209810	211314
28	151505	160620	159384	64	182175	209810	211314
29	154555	165660	163344	65	182235	209850	211544
30	155335	166700	165264	66	182905	210130	212224
31	155915	168740	166824	67	184705	211730	214064
32	158105	173870	169974	68	184705	211730	214064
33	159505	176920	172854	69	184705	211730	214064
34	161005	179810	175464	70	184705	211730	214064
35	162205	182190	177714	71	184705	211730	214064
36	162635	183460	179204	72	184765	211730	214064

Table C-2 Cumulative gas production during experiment (Cont.)

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
73	184795	211730	214104	109	205595	225690	232594
74	186735	213290	215994	110	205595	225690	232594
75	186915	213400	216724	111	205595	225690	232594
76	188265	214760	218384	112	206485	226420	232954
77	188265	214760	218384	113	206485	226420	232954
78	188265	214760	218484	114	206945	226420	232954
79	188265	214760	218484	115	206945	226420	232954
80	188715	214760	218484	116	206945	226420	232954
81	188835	215240	218804	117	207775	226690	233084
82	190955	216850	220814	118	208395	227210	233614
83	192645	218170	222434	119	208395	227210	233614
84	192645	218170	222434	120	208395	227210	233614
85	193175	218170	222834	121	208395	227210	233614
86	194005	218710	223914	122	208395	227210	233614
87	194175	218730	224034	123	208395	227210	233614
88	195105	219510	225114	124	208395	227210	233614
89	195105	219510	225114	125	208395	227210	233614
90	195285	219510	225464	126	209345	228260	234084
91	195285	219510	225464	127	209345	228260	234084
92	195285	219510	225464	128	209345	228260	234084
93	196785	220600	226634	129	209345	228260	234084
94	197855	221460	227744	130	209345	228260	234084
95	198655	221960	228364	131	210445	229640	234414
96	199995	222540	229104	132	210445	229640	234414
97	199995	222540	229104	133	210445	229640	234414
98	200025	222540	229104	134	210445	229640	234414
99	200025	222540	229104	135	210445	229640	234894
100	203005	224780	230704	136	211155	229640	236154
101	203005	224780	230704	137	211155	229640	236154
102	203035	224780	230754	138	211155	229640	236154
103	203035	224780	230754	139	211155	229640	236154
104	203695	224780	231064	140	211155	229640	236154
105	203695	224780	231064	141	211155	229640	236154
106	204745	225050	231944	142	211155	229640	236154
107	204745	225050	231944	143	211435	229830	236224
108	205595	225690	232594	144	211435	229830	236224

Table C-2 Cumulative gas production during experiment (Cont.)

Day	Reactor 1	Reactor 2	Reactor 3	Day	Reactor 1	Reactor 2	Reactor 3
145	211435	230060	236964	180	250140	266780	312549
146	211435	230060	236964	181	251655	271780	315709
147	213735	231940	238804	182	252815	273500	320149
148	214825	232970	239614	183	253915	278100	325999
149	215125	233330	239674	184	254935	279200	330879
150	215355	234670	240254	185	255965	284790	336979
151	215535	235890	241194	186	257165	286470	342219
152	215695	235990	241234	187	258325	287760	343239
153	215695	235990	243804	188	259745	291550	344739
154	217335	238270	245574	189	261285	292630	346389
155	218565	240750	250414	190	262825	293670	347919
156	219105	242090	252994	191	263985	294410	349559
157	221925	242190	255294	192	265075	297950	351559
158	223175	242190	258664	193	266195	300670	353539
159	224875	242850	261064	194	267675	303150	355319
160	226955	243330	265544	195	269335	304560	356299
161	228475	243680	269044				
162	230425	244330	269044				
163	232675	245070	271604				
164	233095	245610	272704				
165	234455	246330	275834				
166	236375	247770	277999				
167	237575	248450	279819				
168	240015	250340	286819				
169	241115	251200	288919				
170	242115	252100	291819				
171	243115	252750	295419				
172	244520	253410	299739				
173	245820	254070	301519				
174	245960	254230	301999				
175	247180	254890	304099				
176	248050	255590	305959				
177	248170	255750	306719				
178	248470	259690	307559				
179	249500	265140	310769				

Table C-3 Cumulative methane production during experiment

Day	Reactor 1	Reactor 2	Reactor 3
148	4578	2575	1782
151	5794	6601	5260
153	5794	6601	20166
155	19939	35121	81150
158	35939	35121	145180
160	84819	43953	277788
162	118905	54353	277788
168	118905	102567	277788
173	152796	125258	339679
176	176018	145306	410842
179	206929	400802	515970
181	258984	620902	641106
183	294107	836228	888502
186	335807	919640	1131900
188	389497	1088105	1397201
194	476862	1193902	1676441

Table C-4 Normalized methane production during experiment

Day	Reactor 1	Reactor 2	Reactor 3
148	4.2	2.5	2.2
151	6.4	3.3	3.7
153	6.2	5	5.8
155	11.5	11.5	12.6
158	12.8	10.3	19
160	23.5	18.4	29.6
162	17.48	16	22.3
168		25.51	
173	26.07	34.38	34.77
176	28.32	28.64	38.26
179	30.01	46.88	32.75
181	34.36	44.02	39.6
183	31.93	46.81	42.29
186	34.75	49.65	46.45
188	37.81	44.45	50.63
194	59.03	42.66	53.29

APPENDIX D

Digestion Procedure for Metal in Leachate by Ethos Sel Installation



APPENDIX D

Digestion Procedure for Metal in Leachate by Ethos Sel Installation

This method provides for the acid digestion of the Wastewater II in a closed vessel device using temperature control microwave heating for the metal determination by spectroscopic methods.

Microwave Equipment

Milestone ETHOS PLUS labstation with HPR-1000/10S high pressure segmented rotor.

Sample Amount Up to 1000 Watt

5 grams

Reagents

6 mL of HNO₃ 65%, 3 ml of HCL 36% and 0.25 Ml of H₂O₂ 30%.

Procedure

1. Place a TFM vessel on the balance plate, tare it and weigh 5 grams of sample.
2. Introduce the THM vessel into the HTC safety shield.
3. Add the acids; if part of the sample stays on the inner wall of the TFM vessel, wet it by adding acids drop by drop, then gently swirl the solution to homogenize the sample with the acids.
4. Close the vessel and introduce it into the rotor segment, then tighten by using the torque wrench.
5. Insert the segment into the microwave cavity and connect the temperature sensor.
6. Run the microwave program to completion.
7. Cool the rotor by air or by water until the solution reaches room temperature.
8. Open the vessel and transfer the solution to a marked flask.

Microwave Program

Step	Time	Temperature	Microwave power
1	10 minutes	200°C	Up to 1000 Watt
2	20 minute	200°C	Up to 1000 Watt

APPENDIX E

Volume of moisture in the simulated landfill reactors

Table E-1 Volume of moisture in reactor 1

Date	Purpose	In	Out	Recycle	Total
Initial water					18,082
12/8/03	COD		120		17,962
13/8/03	DI	120			18,082
14/8/03					
15/8/03	COD		100		17,982
16/8/03					
17/8/03					
18/8/03	COD		100		17,882
19/8/03					
20/8/03					
21/8/03	COD		100		17,782
22/8/03					
23/8/03					
24/8/03	COD		110		17,672
25/8/03					
26/8/03					
27/8/03					
28/8/03	N,P		400		17,272
29/8/03					
30/8/03					
31/8/03					
1/9/03					
2/9/03	COD		60		17,212
3/9/03					
4/9/03					
5/9/03	COD		60		17,152
6/9/03					
7/9/03					
8/9/03	COD		70		17,082
9/9/03					
10/9/03					
11/9/03	COD/S/S		230		16,852
12/9/03					
13/9/03					
14/9/03	COD		60		16,792
15/9/03	ALK		50		16,742
16/9/03	ALK		50		16,692
17/9/03	COD		60		16,632

Table E-1 Volume of moisture in reactor 1 (Cont.)

Date	Purpose	In	Out	Recycle	Total
18/9/03					
19/9/03					
20/9/03					
21/9/03					
22/9/03					
23/9/03	COD		15		16,617
24/9/03					
25/9/03					
26/9/03	COD		60		16,557
27/9/03					
28/9/03					
29/9/03					
30/9/03					
1/10/03	COD		60		16,497
2/10/03					
3/10/03	N,P		300	1,000	16,197
4/10/03					
5/10/03					
6/10/03					
7/10/03				1,000	16,197
8/10/03					
9/10/03					
10/10/03					
11/10/03					
12/10/03					
13/10/03	COD		15		16,182
14/10/03	ALK		30		16,152
15/10/03				1,500	16,152
16/10/03	COD,DI	500	15		16,637
17/10/03					
18/10/03	DI	500			17,137
19/10/03					
20/10/03	COD,DI	500	20		17,617
21/10/03					
22/10/03	DI	500			18,117
23/10/03	COD		25		18,092
24/10/03	DI	500			18,592
25/10/03					
26/10/03					

Table E-1 Volume of moisture in reactor 1 (Cont.)

Date	Purpose	In	Out	Recycle	Total
27/10/03	COD		20		18,572
28/10/03					
29/10/03					
30/10/03	N,P,S/S		500		19,072
31/10/03					
1/11/03					
2/11/03					
3/11/03	COD		15		19,057
4/11/03					
5/11/03					
6/11/03					
7/11/03					
8/11/03					
9/11/03					
10/11/03	COD		10		19,047
11/11/03					
12/11/03					
13/11/03	COD		15		19,032
14/11/03					
15/11/03					
16/11/03					
17/11/03	COD		20		19,012
18/11/03					
19/11/03					
20/11/03	COD		15		18,997
21/11/03					
22/11/03					
23/11/03					
24/11/03	COD		30		18,967
25/11/03					
26/11/03					
27/11/03					
28/11/03	COD				
29/11/03			15		18,952
30/11/03					
1/12/03					
2/12/03	COD,ALK		25		18,927
3/12/03					
4/12/03					

Table E-1 Volume of moisture in reactor 1 (Cont.)

Date	Purpose	In	Out	Recycle	Total
5/12/03	COD		15		18,912
6/12/03					
7/12/03					
8/12/03	N,P,S/S		300		18,612
9/12/03	COD		15		18,597
10/12/03					
11/12/03					
12/12/03					
13/12/03					
14/12/03					
15/12/03					
16/12/03	COD		15		18,582
17/12/03	SLUDGE	2,000			20,582
18/12/03	COD		15		20,567
19/12/03	LEACHATE			1,000	
20/12/03					
21/12/03					
22/12/03					
23/12/03	COD		10		20,557
24/12/03					
25/12/03					
26/12/03					
27/12/03					
28/12/03					
29/12/03					
30/12/03					
31/12/03					
1/1/04					
2/1/04					
3/1/04	SLUDGE	600		600	21,157
4/1/04	SLUDGE	600		600	21,757
5/1/04	LEACHATE			1,000	
6/1/04					
7/1/04	SLUDGE	1,000			22,757
8/1/04	COD		2		22,755
9/1/04	COD		2	1,000	22,753
10/1/04				1,000	
11/1/04				1,000	
12/1/04				1,000	

Table E-1 Volume of moisture in reactor 1 (Cont.)

Date	Purpose	In	Out	Recycle	Total
13/1/04	LEACHATE/HM	1,500	228	900	24,025
14/1/04	COD/LEACHATE		371	900	23,654
15/1/04	LEACHATE		191	900	23,463
16/1/04	COD/LEACHATE		425	900	23,038
17/1/04	LEACHATE		65	900	22,973
18/1/04	LEACHATE		65	900	22,908
19/1/04	LEACHATE		120	900	22,788
20/1/04	COD/LEACHATE		118	900	22,670
21/1/04	LEACHATE		125	900	22,545
22/1/04	LEACHATE		159	900	22,386
23/1/04	LEACHATE		45	900	22,341
24/1/04	LEACHATE			900	
25/1/04	LEACHATE		22	900	22,319
26/1/04	LEACHATE		69	900	22,250
27/1/04	LEACHATE		40	1,200	22,210
28/1/04	LEACHATE		50	1,200	22,160
29/1/04	LEACHATE		48	1,200	22,112
30/1/04	LEACHATE		23	1,200	22,089
31/1/04	LEACHATE		26	1,200	22,063
1/2/04	LEACHATE		20	1,200	22,043
2/2/04	LEACHATE		25	2,650	22,018
3/2/04	LEACHATE		45	2,700	21,973
4/2/04	LEACHATE		53	2,700	21,920
5/2/04	LEACHATE		20	2,700	21,900
6/2/04	LEACHATE		20	2,700	21,880
7/2/04	LEACHATE			2,700	
8/2/04	LEACHATE		20	2,700	21,860
9/2/04	LEACHATE			2,700	
10/2/04	LEACHATE		24	2,700	21,836
11/2/04	LEACHATE			2,700	
12/2/04	LEACHATE		20	2,700	21,816
13/2/04	LEACHATE		420	2,700	21,396
14/2/04	LEACHATE			2,700	
15/2/04	LEACHATE			2,700	
16/2/04	LEACHATE		20	2,700	21,376
17/2/04	LEACHATE		20	2,700	21,356
18/2/04	LEACHATE			2,700	
19/2/04	LEACHATE		15	2,700	21,341
20/2/04	LEACHATE		15	2,700	21,326

Table E-1 Volume of moisture in reactor 1 (Cont.)

Date	Purpose	In	Out	Recycle	Total
21/2/04	LEACHATE			2,700	
22/2/04	LEACHATE			2,700	
23/2/04	LEACHATE			2,700	
24/2/04	LEACHATE			4,500	
25/2/04	LEACHATE		15		21,311

Remark:

DI = Dionize Water

N = Ammonia Nitrogen

P = Orthophosphate

S/S = Sulfides, Sulfates

HM = Heavy metals

ALK= Alkalinity

Table E-2 Volume of moisture in reactor 2

Date	Purpose	In	Out	Recycle	Total
Initial water					18,410
12/8/03	COD		120		18,290
13/8/03	DI	120			18,410
14/8/03					
15/8/03	COD		100		18,310
16/8/03					
17/8/03					
18/8/03	COD		100		18,210
19/8/03					
20/8/03	ALK		131		18,079
21/8/03	COD		100		17,979
22/8/03					
23/8/03					
24/8/03	COD		135		17,844
25/8/03					
26/8/03					
27/8/03					
28/8/03	N,P		400		17,444
29/8/03	COD		40		17,404
30/8/03					
31/8/03					
1/9/03					
2/9/03	COD		60		17,344
3/9/03					
4/9/03					
5/9/03	COD		60		17,284
6/9/03					
7/9/03					
8/9/03	COD		70		17,214
9/9/03					
10/9/03					
11/9/03	COD/S/S		240		16,974
12/9/03					
13/9/03					
14/9/03	COD		60		16,914
15/9/03	ALK		50		16,864
16/9/03	ALK		50		16,814
17/9/03	COD		60		16,754

Table E-2 Volume of moisture in reactor 2 (Cont.)

Date	Purpose	In	Out	Recycle	Total
18/9/03					
19/9/03					
20/9/03					
21/9/03					
22/9/03					
23/9/03	COD		15		16,739
24/9/03					
25/9/03					
26/9/03	COD		60		16,679
27/9/03					
28/9/03					
29/9/03					
30/9/03					
1/10/03	COD		60		16,619
2/10/03					
3/10/03	N,P,RE		300	1,000	16,319
4/10/03					
5/10/03					
6/10/03					
7/10/03	RE			1,000	16,319
8/10/03					
9/10/03					
10/10/03					
11/10/03					
12/10/03					
13/10/03	COD		15		16,304
14/10/03	ALK		30		16,274
15/10/03	RE			1,500	
16/10/03	COD,DI	500	15		16,759
17/10/03					
18/10/03	DI	500			17,259
19/10/03					
20/10/03	COD,DI	500	20		17,739
21/10/03					
22/10/03	DI	500			18,239
23/10/03	COD		25		18,214
24/10/03	DI	500			18,714
25/10/03					

Table E-2 Volume of moisture in reactor 2 (Cont.)

Date	Purpose	In	Out	Recycle	Total
26/10/03					
27/10/03	COD		15		18,699
28/10/03					
29/10/03					
30/10/03	N,P,S,S		500		18,199
31/10/03					
1/11/03					
2/11/03					
3/11/03	COD		15		18,184
4/11/03					
5/11/03					
6/11/03					
7/11/03					
8/11/03					
9/11/03					
10/11/03	COD		15		18,169
11/11/03					
12/11/03					
13/11/03	COD		15		18,154
14/11/03					
15/11/03					
16/11/03					
17/11/03	COD		20		18,134
18/11/03					
19/11/03					
20/11/03	COD		15		18,119
21/11/03					
22/11/03					
23/11/03					
24/11/03	COD		30		18,089
25/11/03					
26/11/03					
27/11/03					
28/11/03	COD		15		18,074
29/11/03					
30/11/03					
1/12/03					

Table E-2 Volume of moisture in reactor 2 (Cont.)

Date	Purpose	In	Out	Recycle	Total
2/12/03	COD,ALK		25		18,049
3/12/03					
4/12/03					
5/12/03	COD		15		18,034
6/12/03					
7/12/03					
8/12/03	N, P, S/S		300		17,734
9/12/03	COD		15		17,719
10/12/03					
11/12/03					
12/12/03					
13/12/03					
14/12/03					
15/12/03					
16/12/03	COD		15		17,704
17/12/03	SLUDGE	2,000			19,704
18/12/03	COD		15		19,689
19/12/03					
20/12/03					
21/12/03					
22/12/03	LEACHATE			1,000	
23/12/03	COD		10		19,679
24/12/03					
25/12/03					
26/12/03					
27/12/03					
28/12/03					
29/12/03					
30/12/03					
31/12/03					
1/1/04					
2/1/04					
3/1/04	SLUDGE	600		600	20,279
4/1/04	SLUDGE	600		600	20,879
5/1/04	LEACHATE			1,000	
6/1/04					
7/1/04	SLUDGE	1,000			21,879
8/1/04			2		21,877

Table E-2 Volume of moisture in reactor 2 (Cont.)

Date	Purpose	In	Out	Recycle	Total
9/1/04	LEACHATE		2	1,000	21,875
10/1/04				1,000	
11/1/04				1,000	
12/1/04				1,000	
13/1/04				900	
14/1/04	LEACHATE		2	900	21,873
15/1/04	LEACHATE			900	
16/1/04	COD/ LEACHATE		300	900	21,573
17/1/04	LEACHATE			900	
18/1/04	LEACHATE			900	
19/1/04	LEACHATE			900	
20/1/04	LEACHATE			900	
21/1/04	LEACHATE			900	
22/1/04	LEACHATE			900	
23/1/04	LEACHATE			900	
24/1/04	LEACHATE			900	
25/1/04	LEACHATE			900	
26/1/04	LEACHATE			900	
27/1/04	LEACHATE			1,200	
28/1/04	LEACHATE			1,200	
29/1/04	LEACHATE			1,200	
30/1/04	LEACHATE			1,200	
31/1/04	LEACHATE			1,200	
1/2/04	LEACHATE			1,200	
2/2/04	LEACHATE			2,700	
3/2/04	LEACHATE			2,700	
4/2/04	LEACHATE			2,700	
5/2/04	LEACHATE			2,700	
6/2/04	LEACHATE			2,700	
9/2/04	LEACHATE			4,500	
10/2/04	LEACHATE			4,500	
11/2/04	LEACHATE/HM	1,500	256	4,500	23,073
12/2/04	LEACHATE		334	4,500	22,739
13/2/04	LEACHATE		547	4,500	22,192
14/2/04	LEACHATE		48	4,500	22,144
15/2/04	LEACHATE		45	4,500	22,099
16/2/04	LEACHATE		104	4,500	21,995

Table E-2 Volume of moisture in reactor 2 (Cont.)

Date	Purpose	In	Out	Recycle	Total
17/2/04	LEACHATE		86	4,500	21,909
18/2/04	LEACHATE		55	4,500	21,854
19/2/04	LEACHATE		36	4,500	21,818
20/2/04	LEACHATE		57	4,500	21,761
21/2/04	LEACHATE		40	4,500	21,721
22/2/04	LEACHATE		35	4,500	21,686
23/2/04	LEACHATE		20	4,500	21,666
24/2/04	LEACHATE		84	4,500	21,582
25/2/04	LEACHATE		62		21,582

Remark:

DI = Dionize Water

N = Ammonia Nitrogen

P = Orthophosphate

S/S = Sulfides, Sulfates

HM = Heavy metals

ALK= Alkalinity

Table E-3 Volume of moisture in reactor 3

Date	Purpose	In	Out	Recycle	Total
Initial water					18,540
12/8/03	COD		120		18,420
13/8/03	DI	120			18,540
14/8/03					
15/8/03	COD		100		18,440
16/8/03					
17/8/03					
18/8/03	COD		100		18,340
19/8/03					
20/8/03	ALK		100		18,220
21/8/03					
22/8/03					
23/8/03					
24/8/03	COD		120		18,100
25/8/03					
26/8/03					
27/8/03					
28/8/03	N,P		300		17,800
29/8/03	COD		40		17,760
30/8/03					
31/8/03					
1/9/03					
2/9/03	COD		60		17,700
3/9/03					
4/9/03					
5/9/03	COD		60		17,640
6/9/03					
7/9/03					
8/9/03	COD		70		17,570
9/9/03					
10/9/03					
11/9/03					
12/9/03					
13/9/03					
14/9/03	COD		60		17,510
15/9/03	ALK		60		17,450
16/9/03	ALK		50		17,400
17/9/03	COD		60		17,340

Table E-3 Volume of moisture in reactor 3 (Cont.)

Date	Purpose	In	Out	Recycle	Total
18/9/03					
19/9/03					
20/9/03					
21/9/03					
22/9/03					
23/9/03	COD		15		17,325
24/9/03					
25/9/03					
26/9/03	COD		60		17,265
27/9/03					
28/9/03					
29/9/03					
30/9/03					
1/10/03	COD		60		17,205
2/10/03					
3/10/03	N,P,RE		300	1,000	16,905
4/10/03					
5/10/03					
6/10/03					
7/10/03	RE			1,000	
8/10/03					
9/10/03					
10/10/03					
11/10/03					
12/10/03					
13/10/03	COD		15		16,890
14/10/03	ALK		30		16,860
15/10/03	RE			1,500	
16/10/03	COD,DI	500	10		17,350
17/10/03					
18/10/03	DI	500			17,850
19/10/03					
20/10/03	COD,DI	500	20		18,330
21/10/03					
22/10/03	DI	500			18,830
23/10/03	COD		25		18,805
24/10/03	DI	500			19,305
25/10/03					

Table E-3 Volume of moisture in reactor 3 (Cont.)

Date	Purpose	In	Out	Recycle	Total
26/10/03					
27/10/03	COD		20		19,285
28/10/03					
29/10/03					
30/10/03	N,P		300		18,985
31/10/03					
1/11/03					
2/11/03					
3/11/03	COD		15		18,970
4/11/03					
5/11/03					
6/11/03					
7/11/03					
8/11/03					
9/11/03					
10/11/03	COD		15		18,955
11/11/03					
12/11/03					
13/11/03	COD		15		18,940
14/11/03					
15/11/03					
16/11/03					
17/11/03	COD		30		18,910
18/11/03					
19/11/03					
20/11/03	COD		20		18,890
21/11/03					
22/11/03					
23/11/03					
24/11/03	COD		30		18,860
25/11/03					
26/11/03					
27/11/03					
28/11/03	COD		30		18,830
29/11/03					
30/11/03					
1/12/03					

Table E-3 Volume of moisture in reactor 3 (Cont.)

Date	Purpose	In	Out	Recycle	Total
2/12/03	COD,ALK		15		18,815
3/12/03					
4/12/03					
5/12/03	COD		25		18,790
6/12/03					
7/12/03			15		18,775
8/12/03	N, P		300		18,475
9/12/03	COD		15		18,460
10/12/03					
11/12/03					
12/12/03					
13/12/03					
14/12/03					
15/12/03					
16/12/03	COD		15		18,445
17/12/03	SLUDGE	2,000			20,445
18/12/03	COD		15		20,430
19/12/03					
20/12/03					
21/12/03					
22/12/03	LEACHATE			1,000	
23/12/03	COD		10		20,420
24/12/03					
25/12/03					
26/12/03			15		20,405
27/12/03					
28/12/03					
29/12/03					
30/12/03					
31/12/03					
1/1/04					
2/1/04					
3/1/04	SLUDGE	600		600	21,005
4/1/04	SLUDGE	600		600	21,605
5/1/04	LEACHATE			1,000	
6/1/04					
7/1/04	SLUDGE	1,000			22,605
8/1/04			2		22,603

Table E-3 Volume of moisture in reactor 3 (Cont.)

Date	Purpose	In	Out	Recycle	Total
9/1/04	LEACHATE		5	1,000	22,598
10/1/04				1,000	
11/1/04				1,000	
12/1/04				1,000	
13/1/04				900	
14/1/04	LEACHATE		1	900	22,597
15/1/04	LEACHATE			900	
16/1/04	LEACHATE			900	
17/1/04	LEACHATE		1	900	22,596
18/1/04	LEACHATE			900	
19/1/04	LEACHATE			900	
20/1/04	LEACHATE /COD		8	900	22,588
21/1/04	LEACHATE			900	
22/1/04	LEACHATE			900	
23/1/04	LEACHATE			900	
24/1/04	LEACHATE			900	
25/1/04	LEACHATE			900	
26/1/04	LEACHATE			900	
27/1/04	LEACHATE			1,200	
28/1/04	LEACHATE			1,200	
29/1/04	LEACHATE			1,200	
30/1/04	LEACHATE			1,200	
31/1/04	LEACHATE			1,200	
1/2/04	LEACHATE			1,200	
2/2/04	LEACHATE			2,700	
3/2/04	LEACHATE			2,700	
4/2/04	LEACHATE			2,700	
5/2/04	LEACHATE			2,700	
6/2/04	LEACHATE N,P		300	2,700	22,288
9/2/04	LEACHATE			2,700	
10/2/04	LEACHATE			2,700	
11/2/04	LEACHATE			2,700	
12/2/04	LEACHATE			4,500	
13/2/04	LEACHATE			4,500	
14/2/04	LEACHATE			4,500	
15/2/04	LEACHATE			4,500	
16/2/04	LEACHATE		6	4,500	22,282

Table E-3 Volume of moisture in reactor 3 (Cont.)

Date	Purpose	In	Out	Recycle	Total
17/2/04	LEACHATE			4,500	
18/2/04	LEACHATE			4,500	
19/2/04	LEACHATE		6	4,500	22,276

Remark:

DI = Dionize Water

N = Ammonia Nitrogen

P = Orthophosphate

S/S = Sulfides, Sulfates

HM = Heavy metals

ALK= Alkalinity

APPENDIX F**Nickel and Zinc concentrations in Acidogenic Phase and Methanogenic Phase**

Table F-1 Nickel and Zinc concentrations in Acidogenic Phase

Day	Time	Hour	Nickel (mg/L)		Zinc (mg/L)	
			Actual Value	Diluted Value	Actual Value	Diluted Value
13/1/04	11.30	0	0.043	0.215	0.175	0.875
13/1/04	12.30	1	0.051	0.255	0.063	0.315
13/1/04	13.30	2	0.036	0.180	0.065	0.325
13/1/04	14.30	3	0.036	0.180	0.039	0.195
13/1/04	15.30	4	0.030	0.150	0.042	0.210
13/1/04	16.30	5	0.709	3.545	0.715	3.575
13/1/04	17.30	6	0.466	2.330	0.469	2.345
13/1/04	18.30	7	0.232	1.160	0.258	1.290
13/1/04	19.30	8	0.256	1.280	0.261	1.305
13/1/04	21.30	10	0.096	0.480	0.146	0.730
13/1/04	22.30	11	0.080	0.400	0.100	0.500
13/1/04	23.30	12	0.087	0.435	0.103	0.515
14/1/04	0.30	13	0.082	0.410	0.180	0.900
14/1/04	1.30	14	0.078	0.390	0.100	0.500
14/1/04	2.30	15	0.090	0.450	0.119	0.595
14/1/04	4.30	17	0.092	0.460	0.135	0.675
14/1/04	6.30	19	0.099	0.495	0.170	0.850
14/1/04	7.30	20	0.098	0.490	0.112	0.560
14/1/04	8.30	21	0.118	0.590	0.149	0.745
14/1/04	9.30	22	0.093	0.465	0.155	0.775
14/1/04	11.30	24	0.111	0.555	0.224	1.120
14/1/04	12.30	25	0.129	0.645	0.164	0.820
14/1/04	13.30	26	0.151	0.755	0.941	4.705
14/1/04	14.30	27	0.159	0.795	0.168	0.840
14/1/04	15.30	28	0.176	0.880	0.272	1.360
14/1/04	17.30	30	2.070	10.350	1.680	8.400
14/1/04	18.30	31	3.390	16.950	2.250	11.250
14/1/04	20.30	33	5.940	29.700	3.770	18.850
14/1/04	22.30	35	6.560	32.800	4.040	20.200
15/1/04	0.30	37	6.280	31.400	3.780	18.900
15/1/04	2.30	39	6.010	30.050	3.600	18.000
15/1/04	4.30	41	4.790	23.950	2.910	14.550
15/1/04	6.30	43	4.050	20.250	2.400	12.000
15/1/04	8.30	45	3.390	16.950	2.000	10.000
15/1/04	10.30	47	3.140	15.700	1.900	9.500

Table F-1 Nickel and Zinc concentrations in Acidogenic Phase (Cont.)

Day	Time	Hour	Nickel (mg/L)		Zinc (mg/L)	
			Actual Value	Diluted Value	Actual Value	Diluted Value
15/1/04	12.30	49	3.150	15.750	1.890	9.450
15/1/04	14.30	51	3.480	17.400	2.080	10.400
16/1/04	16.30	53	3.750	18.750	2.190	10.950
16/1/04	8.30	68	10.310	51.550	7.660	38.300
16/1/04	10.30	70	15.260	76.300	10.200	51.000
16/1/04	12.30	72	14.600	73.000	10.090	50.450
16/1/04	14.30	74	14.420	72.100	9.520	47.600
16/1/04	16.30	76	13.790	68.950	8.550	42.750
17/1/04	18.30	78	13.430	67.150	8.140	40.700
17/1/04	1.30	84	15.670	78.350	11.150	55.750
17/1/04	8.30	91	16.350	81.750	10.090	50.450
18/1/04	16.30	99	16.050	80.250	9.150	45.750
18/1/04	12.30	119	15.990	79.950	9.180	45.900
18/1/04	14.30	121	16.500	82.500	11.440	57.200
19/1/04	17.30	124	17.060	85.300	10.250	51.250
19/1/04	8.30	139	15.290	76.450	8.590	42.950
19/1/04	10.30	141	15.890	79.450	8.280	41.400
19/1/04	12.30	143	15.880	79.400	8.090	40.450
19/1/04	14.30	145	15.490	77.450	7.820	39.100
20/1/04	16.30	147	16.190	80.950	8.270	41.350
21/1/04	9.30	164	15.820	79.100	9.590	47.950
22/1/04	0.30	179	15.600	78.000	8.100	40.500
23/1/04	0.30	191	14.860	74.300	6.950	34.750
25/1/04	9.00	199	15.200	76.000	7.030	35.150
26/1/04	15.00	205	14.620	73.100	7.260	36.300
27/1/04	10.00	224	14.460	72.300	6.550	32.750
28/1/04	10.00	243	13.460	67.300	5.800	29.000
29/1/04	10.30	262	13.240	66.200	5.640	28.200
30/1/04	10.30	281	13.040	65.200	4.200	21.000
31/1/04	12.00	282	12.580	62.900	3.960	19.800
1/2/04	10.30	304	12.270	61.350	4.030	20.150
2/2/04	15.30	309	9.990	49.950	3.090	15.450
3/2/04	9.30	327	12.530	62.650	3.840	19.200
4/2/04	10.30	352	11.130	55.650	2.560	12.800
15/1/04	11.00	377	7.420	37.100	0.948	4.740

Table F-1 Nickel and Zinc concentrations in Acidogenic Phase (Cont.)

Day	Time	Hour	Nickel (mg/L)		Zinc (mg/L)	
			Actual Value	Diluted Value	Actual Value	Diluted Value
5/2/04	11.30	403	10.480	52.400	2.100	10.500
6/2/04	10.00	425	9.910	49.550	1.560	7.800
8/2/04	9.30	448	6.320	31.600	0.706	3.530
10/2/04	11.00	497	3.650	36.50	0.318	3.18
13/2/04	10.00	568	2.600	26	0.165	1.65
17/2/04	10.30	665	1.530	15.30	0.168	1.68
20/2/04	9.30	736	0.392	3.92	0.175	1.75
25/2/04	10.00	856	0.297	2.97	0.193	1.93

Table F-2 Nickel and Zinc concentrations during Methanogenic Phase

Day	Time	Hour	Nickel (mg/L)		Zinc (mg/L)	
			Actual Value	Diluted Value	Actual Value	Diluted Value
11/2/04	13.00	1	0.115	1.15	0.388	3.88
11/2/04	14.00	2	0.596	5.96	1.16	11.6
11/2/04	15.00	3	0.777	7.77	1.35	13.5
11/2/04	16.00	4	1.94	19.4	2.18	21.8
11/2/04	17.00	5	2.74	27.4	2.54	25.4
11/2/04	18.00	6	2.79	27.9	2.65	26.5
11/2/04	19.00	7	3.18	31.8	2.84	28.4
11/2/04	20.00	8	3.7	37	3.03	30.3
11/2/04	21.00	9	3.15	31.5	2.63	26.3
11/2/04	22.00	10	3.67	36.7	2.86	28.6
11/2/04	23.00	11	3.96	39.6	3.12	31.2
11/2/04	24.00	12	4.3	43	3.28	32.8
12/2/04	1.00	13	3.06	30.6	4.35	43.5
12/2/04	2.00	14	4.65	46.5	2.99	29.9
12/2/04	3.00	15	4.98	49.8	2.98	29.8
12/2/04	4.00	16	5.3	53	3.09	30.9
12/2/04	5.00	17	5.64	56.4	3.62	36.2
12/2/04	6.00	18	5.73	57.3	3.46	34.6
12/2/04	7.00	19	6.05	60.5	3.47	34.7
12/2/04	8.00	20	6.31	63.1	3.47	34.7
12/2/04	9.00	21	6.49	64.9	3.3	33
12/2/04	10.00	22	6.34	63.4	3.14	31.4
12/2/04	11.00	23	6.34	63.4	3.18	31.8
12/2/04	12.00	24	6.82	68.2	5.47	54.7
12/2/04	14.00	26	6.57	65.7	4.62	46.2
12/2/04	18.00	30	6.53	65.3	3.28	32.8
12/2/04	22.00	34	6.13	61.3	3.21	32.1
13/2/04	0.00	36	6.1	61	3	30
13/2/04	2.00	38	5.92	59.2	2.98	29.8
13/2/04	5.00	41	5.77	57.7	2.94	29.4
13/2/04	8.00	44	5.7	57	3.12	31.2
13/2/04	12.00	48	5.51	55.1	1.65	16.5
13/2/04	14.00	50	5.5	55	1.71	17.1
13/2/04	17.00	53	5.25	52.5	1.39	13.9
14/2/04	13.00	73	5.43	54.3	3.15	31.5
14/2/04	15.30	75.3	4.58	45.8	1.24	12.4

Table F-2 Nickel and Zinc concentrations during Methanogenic Phase (Cont.)

Day	Time	Hour	Nickel (mg/L)		Zinc (mg/L)	
			Actual Value	Diluted Value	Actual Value	Diluted Value
15/2/04	13.00	97	5.11	51.1	1.79	17.9
15/2/04	15.30	99.3	4.61	46.1	1.29	12.9
16/2/04	8.30	116	4.17	41.7	1.18	11.8
16/2/04	10.30	118	4.22	42.2	0.998	9.98
16/2/04	12.30	120	4.29	42.9	0.963	9.63
16/2/04	21.00	129	4.03	40.3	0.88	8.8
17/2/04	8.30	140	3.77	37.7	1.13	11.3
17/2/04	14.30	147	3.78	37.8	1.01	10.1
17/2/04	17.00	149	3.88	38.8	1.69	16.9
18/2/04	9.00	165	3.58	35.8	1.36	13.6
18/2/04	14.00	170	3.26	32.6	0.909	9.09
18/2/04	17.00	173	3.81	38.1	1.81	18.1
19/2/04	10.30	190	3.32	33.2	1.2	12
19/2/04	14.30	194	2.61	26.1	0.746	7.46
20/2/04	12.30	216	2.43	24.3	0.713	7.13
20/2/04	15.30	219	1.92	19.2	0.711	7.11
21/2/04	1.00	228	1.86	18.6	0.634	6.34
21/2/04	8.00	235	1.6	16	0.629	6.29
22/2/04	13.00	264	1.46	14.6	0.882	8.82
22/2/04	17.30	268	1.39	13.9	0.809	8.09
23/2/04	13.30	287	1.24	12.4	0.687	6.87
24/2/04	9.00	306	1.26	12.6	0.705	7.05
24/2/04	12.00	309	1.07	10.7	0.566	5.66
24/2/04	16.30	314	0.976	9.76	0.508	5.08
25/2/04	10.00	330	1.12	11.2	0.6	6
25/2/04	12.00	332	0.914	9.14	0.497	4.97
25/2/04	15.00	335	0.974	9.74	0.579	5.79

APPENDIX G

Computation of water and heavy metal loading into the reactors

APPENDIX G

Computation of water and heavy metal loading into the reactors.

1. Volume of water in the system

Moisture content = 90%

Weight of waste = 20 kg

$$\therefore \text{volume of water} = 20 \times (90/100) = 18 \text{ L}$$

2. % of field capacity in system

Weight of waste = 20 kg

Water = 18 L

solid waste = 2 kg

sludge seeding = 1 L

leachate (first day) = 3.8 L

$$\therefore \text{Total water in system} = (18+1) - 3.8 = 15.2 \text{ L}$$

$$\begin{aligned} \therefore \text{\% of field capacity in system} &= (15.2/20) \times 100 \\ &= 76\% \end{aligned}$$

3. Leachate recirculation shift phase condition

Volume of water in system = 18 L

$$\begin{aligned} \therefore 5\% \text{ of available moisture} &= 18 \times (5/100) \\ &= 0.9 \text{ L} \end{aligned}$$

$$\begin{aligned} \therefore 15\% \text{ of available moisture} &= 18 \times (15/100) \\ &= 2.7 \text{ L} \end{aligned}$$

$$\begin{aligned} \therefore 25\% \text{ of available moisture} &= 18 \times (25/100) \\ &= 4.5 \text{ L} \end{aligned}$$

4. Masses of the selected heavy metals loadings into the reactors.

Allowable amount according to Turkish Hazardous Waste Control Regulation
= 100 g/t MSW (Ni, Zn)

Weight of solid waste = 20 kg

∴ Allowable amount of heavy metals in system = 2 g

Amount of Metal salt will be loaded in reactor

Atomic weight of Ni = 58.69

Atomic weight of NiCl₂·6H₂O = 237.59

Allowable amount of heavy metals in system = 2 g

∴ NiCl₂·6H₂O will be used in reactor = $(237.59/58.69) \times 2$
= 8.09 g

Atomic weight of Zn = 65.38

Atomic weight of ZnCl₂ = 136.286

Allowable amount of heavy metals in system = 2 g

∴ ZnCl₂ will be used in reactor = $(136.286/65.38) \times 2$
= 4.16 g



BIOGRAPHY

Miss Patummart Chewha was born on Dec 11, 1979 in Nakornprathom Province, Thailand. She graduated from Mahidol Vidhyanusorn School in Nakornpathom in 1998. She received her Bachelor's Degree in Environmental Science Technology from Faculty of Science, Sirinthorn International Institute of Technology, Thammasart University in 2002. She pursued her Master Degree study in the International Postgraduate Programs in Environmental Management, Inter-Department of Environmental, Chulalongkorn University, Bangkok, Thailand in May 2002. She finished her Master Degree of Science in Environment Management in May 2004.